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भाग 5 रिसीवर नियोजन एक-पार्श्वीय बंड तकनीकें
(आर3ई, एच3ई या जे3ई)

Indian Standard

METHODS OF MEASUREMENT FOR RADIO EQUIPMENT USED IN THE MOBILE SERVICES

PART 5 RECEIVERS EMPLOYING SINGLE-SIDEBAND TECHNIQUES (R3E, H3E OR J3E)

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NATIONAL FOREWORD

This Indian Standard which is identical with IEC Pub 489-5 (1987) 'Methods of measurement for radio equipment used in the mobile services — Part 5 : Receivers employing single-sideband techniques (R3E, H3E or J3E)', issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Radiocommunication Sectional Committee (LTD 20) and approval of the Electronics and Telecommunication Division Council.

In the adopted standard certain terminology and conventions are however not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards the current practice is to use a point (.).

In this Indian Standard, the following International Standard is referred to. Read in its place the following:

International Standard	*Indian Standard*
IEC Pub 489 - 1 (1983) Methods of measurement for radio equipment used in the mobile services — Part 1 : General conditions and standard conditions of measurement	IS 10820 (Part 1) : 1984 Methods of measurement for radio equipment used in the mobile services : Part 1 General conditions and standard conditions of measurement (Technically equivalent)

The technical committee responsible for the preparation of this standard has reviewed the provisions of the following international publications and has decided that they are acceptable for use in conjunction with this standard:

IEC Pub 315 - 1 (1970) Methods of measurement on radio receivers for various classes of emission — Part 1 : General conditions for measurement and measuring methods applying to several types of receivers

IEC Pub 315 - 2 (1971) Methods of measurement on radio receivers for various classes of emission — Part 2 : Measurement particularly related to the audio- frequency part of a receiver

The technical committee has also indicated that under clause 18.2, last line 'receiver input' should be read in place of 'receiver output'

Only the English language text in the International Standard has been retained while adopting it in this standard.

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SECTION ONE – GENERAL

1. Scope

This standard refers specifically to mobile radio receivers having audio-frequency bandwidths generally not exceeding 10 kHz for the reception of voice and other types of signals, using single-sideband amplitude modulation.

This standard is intended to be used in conjunction with IEC Publication 489-1. The supplementary terms and definitions and the conditions of measurement set forth in this standard are intended for type tests and may be used also for acceptance tests.

2. Object

The object of this standard is to standardize the definitions, the conditions and the methods of measurement used to ascertain the performance of receivers within the scope of this standard and to make possible a meaningful comparison of the results of measurements made by different observers and on different equipment.

SECTION TWO – SUPPLEMENTARY DEFINITIONS AND CONDITIONS OF MEASUREMENT

3. Supplementary terms and definitions

For the purpose of this standard, the following supplementary definitions apply.

3.1 *Output level*

3.1.1 *Rated output level*

The level, as defined in the equipment specifications, corresponding to:

- the power at the audio output terminals when these are connected to a specified load

  or
- the voltage appearing across the output transducer
  or
- the sound pressure.

In the absence of a value specified by the manufacturer, the rated output level is 3 dB below the maximum output level.

3.1.2 *Reference output level*

a) Where there is a continuously variable gain control, the reference output level is that which is 6 dB below the rated output level.

b) Where there is step-by-step output control, the reference output level is that closest to the level defined in Step *a)* above.

c) Where there is no gain control, the reference output level is the level obtained when a standard input signal is applied to the receiver.

3.2 *Audio-frequency load*

For equipment with an integral audio-frequency output transducer, the load is the output transducer.

Note. – The manufacturer should specify the method of connection and state the impedance (and tolerance) of the output transducer at 1000 Hz. It is desirable also to state the impedance at specified upper and lower audio-frequency band limits.

3.2.1 *Audio-frequency test load*

An impedance network which replaces the load to which the receiver is connected under normal operating conditions. It simulates the impedance of the normal load and any cables with which it is normally used.

Note. – The network shall be specified by the manufacturer. It usually consists of a single pure resistance.

3.3 *Standard signal-to-noise ratio*

Ratio of:

the power of the signal-plus-noise-plus-distortion
to
the power of the noise-plus-distortion
at the test load.

This ratio is abbreviated as:

$$\frac{S+N+D}{N+D}$$

where:

S is the wanted audio-frequency signal due to standard test modulation
N is the noise with standard test modulation
D is the distortion with standard test modulation

It is expressed in decibels and is often referred to as SINAD.

The value of the standard signal-to-noise ratio is 12 dB.

The standard signal-to-noise ratio allows comparison between different equipment when the standard test modulation is used.

Note. – Other types and values of signal-to-noise ratio may be used by agreement between the purchaser and the manufacturer.

3.4 *Radiation sensitivity of a receiver with an integral antenna, in a given direction (field strength)*

The field strength required to produce the standard signal-to-noise ratio under specified conditions of operation.

Notes 1. – An integral antenna is an antenna which is considered to be an integral part of the equipment. In some cases, the receiver operates with the antenna inside the housing and in others with the antenna mounted on the exterior of the housing.

2. – For certain applications, another characteristic, for example, the squelch opening level, may be specified.

3. – In this publication, the term "antenna" is synonymous with "aerial".

3.5 *De-emphasis*

The process intended to restore the original form of a signal which has been transmitted with pre-emphasis.

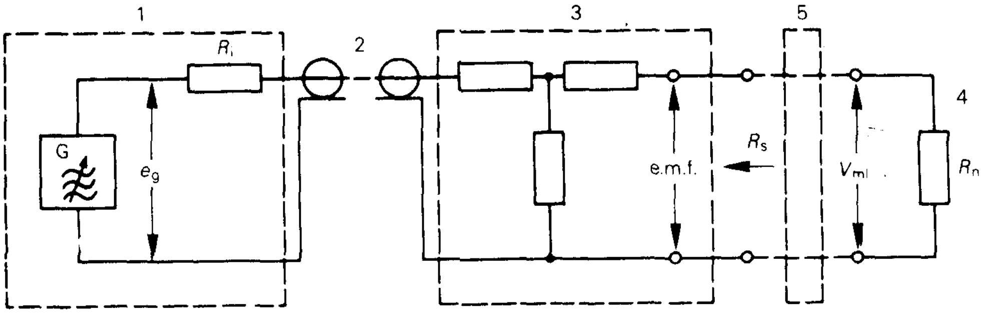
Note. – Pre-emphasis may be applied before modulation.

4. Standard test conditions

Unless otherwise stated, measurements shall be performed under the general test conditions as stated in IEC Publication 489-1 and the supplementary test conditions given below.

5. Supplementary test conditions

5.1 *Input-signal arrangements for testing receivers equipped with suitable antenna terminals*



1 = radio-frequency signal generator with source impedance R_i
2 = transmission line
3 = impedance matching network (pad)
4 = nominal input impedance of receiver: R_n
5 = artificial antenna (where required)
R_s = impedance of the input-signal source

FIG. 1. – Input-signal source arrangement.

The nominal radio-frequency input impedance (R_n) is that value stated by the manufacturer for which the equipment performance will be optimum when connected to an antenna of the same impedance.

The input-signal level should preferably be expressed as: the electromotive force (e. m. f.) present at the output of the unterminated input-signal source (e.m.f. of Figure 1) when the input-signal source impedance (R_s) is equal to the nominal radio-frequency input impedance (R_n) of the receiver.

Alternatively, the input-signal may be expressed as the matched-load (V_{ml}) voltage measured across an impedance having a value equal to R_n, when the source impedance (R_s) is equal to the nominal radio-frequency input impedance (R_n).

The matched-load voltage (V_{ml}) is one-half the value of the e.m.f.

When the meter that indicates the value of e_g is not in close proximity to the receiver input terminals, the transmission line loss shall be taken into account in addition to the loss of the impedance matching network.

5.1.1 *Input-signal source for receivers requiring a specified source resistance*

This sub-clause applies to receivers which are connected to the antenna by means of a transmission line (which is synonymous with "feeder line").

The input-signal source shall consist of a radio-frequency signal generator, a transmission line, and an impedance-matching network (pad) placed as close as possible to the receiver under test (see Figure 1, page 13).

5.1.2 *Input-signal source receivers tested with the aid of an artificial antenna*

This sub-clause is applicable to receivers intended to operate with an antenna having a complex impedance.

The input-signal source shall consist of a radio-frequency signal generator, a transmission line, an impedance matching network and an artificial antenna. The characteristics of the artificial antenna shall be specified by the manufacturer of the receiver.

5.2 *Input-signal level*

The input-signal level of the wanted signal shall be expressed as the r.m.s. value of a sinusoidal voltage, the peak value of which is equal to the amplitude of one radio-frequency cycle at the crest of the envelope of the modulation wave.

Note. – The input signal consisting of a carrier and a sideband component as specified in Sub-clause 5.3 should be expressed in terms of the sum of the r.m.s. voltages.

The input-signal level of any unmodulated unwanted signal shall be expressed in terms of its r.m.s. voltage.

The input levels of the wanted and unwanted signals shall be recorded in μV or dB (μV).

5.2.1 *Receivers requiring a specific source resistance*

The presentation of results should state whether the electromotive force of the source of the matched-load (V_{ml}) voltage has been recorded, for example 2 μV (e.m.f.) or 1 μV (V_{ml}). The source resistance (R_s) should also be stated. (See Figure 1.)

5.2.2 *Receivers tested with the aid of an artificial antenna*

The input-signal level is the e.m.f. of the source connected to the input terminals of an artificial antenna.

5.3 *Standard input signal*

A radio-frequency signal or a linear combination of two radio-frequency signals from a signal source that simulates the single-sideband emission from a transmitter when it is modulated with an audio-frequency signal of 1 000 Hz.

The frequencies and the levels of the input signal are dependent upon the class of emission they represent. Two frequencies, one of which represents the carrier and the other which represents the sideband, are chosen such that when demodulated they will produce an audio output at a frequency of 1 000 Hz.

The standard input-signal levels are:

Class of emission	Signal representing the	
	Carrier	Sideband
R3E H3E J3E	+42 dB (µV) +54 dB (µV) Omit or +20 dB (µV), as specified	+60 dB (µV) +54 dB (µV) +60 dB (µV)

5.4 *Networks for combining several signal sources*

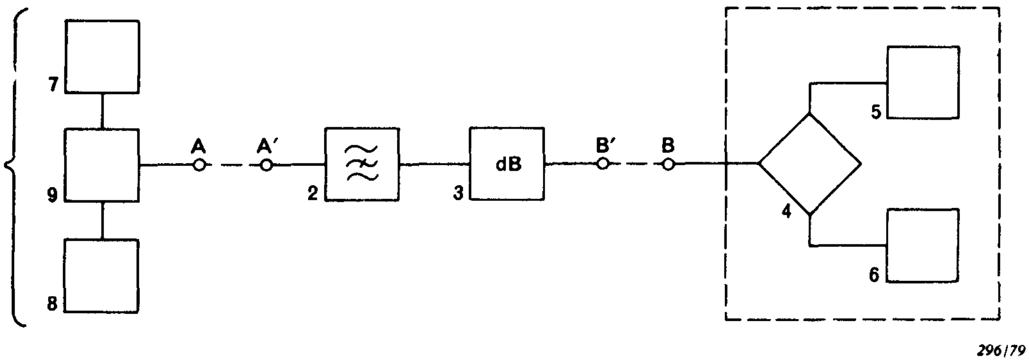
Examples of combining networks may be found in Appendix A.

5.5 *Input-signal arrangements for testing the receiving part of equipment for duplex operation*

When the performance of the receiver section of equipment for duplex operation is to be evaluated while the associated transmitter section is operating, precautions should be taken in order to ensure that the operation of the signal generator or generators used for testing the receiver section is not affected by the radio-frequency signal of the transmitter section and that the latter is terminated by its proper load impedance.

5.5.1 *Input-signal source*

An example of a suitable arrangement for making measurements on receivers of equipment for duplex operation is shown in Figure 2.



1 = input-signal source
2 = band-stop filter
3 = attenuator
4 = combining unit belonging to the equipment under test
5 = transmitting part of the equipment
6 = receiving part of the equipment
7 = radio-frequency signal generator
8 = radio-frequency signal generator
9 = radio-frequency combining network

FIG. 2. – Example of an arrangement for testing receivers for duplex operation.

Connect the input-signal source (1) (levels adjusted according to Sub-clause 5.3) to point A′. The centre frequency of the band-stop filter (2) is adjusted to the operating frequency of the transmitter under test.

The impedance at point B′ shall be such that the transmitter section is operating under the specified matched conditions. To ensure that the V. S. W. R. will be less than 1.25, irrespective of any mismatch caused by the band-stop filter (2) and the combining unit (4), the attenuation of the attenuator (3) should be at least 30 dB. It should be noted that the attenuator will dissipate nearly all of the power from the transmitter section and therefore must have suitable power-handling capacity.

5.5.2 *Input-signal level*

The level of the r. f. input signal shall be determined at point B′ of Figure 2, page 17.

5.6 *Input-signal arrangements for testing receivers having an integral antenna*

For receivers provided with an integral antenna and for equipment which has no facilities suitable for connecting the measuring equipment, the input-signal source will include the antenna specified by the manufacturer. For absolute measurements, a radiation test site where the field strength of the test signals is known should be used. For relative measurements, a radio-frequency coupling device (RFCD) may be used.

5.7 *Connection of the measuring equipment*

Care must be taken that the input impedance of the measuring equipment does not affect the loading conditions specified for the receiver.

5.7.1 *Limitation of the audio-frequency band*

Because some properties, for example, noise and audio-frequency harmonic distortion, depend upon the audio-frequency bandwidth, reproducible results can be obtained only when the band of audio frequencies occupied by the demodulated signal is restricted to specified limits.

This restriction may be accomplished by means of a band-limiting filter preceding any audio-frequency measuring device. The filter may be incorporated within the measuring equipment. When measuring residual hum and noise, only the low-pass portion of the filter need be specified.

5.8 *Squelch condition*

The circuit should be adjusted for the unsquelched condition unless otherwise specified.

Note. – The term "squelch" is synonymous with "mute".

5.9 *De-emphasis condition*

De-emphasis, if used, should be operative for all tests.

5.10 *Instrument input impedance*

Depending upon requirement, the measuring instrument (13) or (14), in Figure 7, page 84, 85, may be either a distortion factor/audio level meter (13) or a selective measuring device (14). The input impedance Z_2 of the band-limiting filter (12), in Figure 7, should be much greater than Z_1. If the band-limiting filter (12) is not used, the input impedance of the measuring device (13) or (14) should be much greater than Z_1.

6. Characteristics of the measuring equipment

Note. – For supplementary methods for testing measuring arrangements, refer to Appendix B.

6.1 *True r. m. s. voltage meter*

For the measurement of the signal-to-noise ratio, the characteristics of the indicating meter are important. In addition, for certain characteristics, measurement of the true r. m. s. voltage is required.

6.2 *Distortion-factor meter or SINAD meter*

The distortion-factor meter or SINAD meter shall have the following characteristics:

- The wide-band response shall not vary more than 0.1 dB over the frequency range 50 Hz to 20000 Hz.
- The band elimination filter attenuation shall be at least 40 dB at 1000 Hz, but not more than 0.5 dB between 50 Hz and 500 Hz and between 2000 Hz and 20000 Hz.

Note. – If the SINAD meter has a fixed filter, it should have 40 dB attenuation over a frequency band of 980 Hz to 1020 Hz.

- The noise signal level from a constant amplitude noise source between 300 Hz and 3000 Hz shall not be attenuated by more than 1 dB by the filter.
- The indicator shall be a true r. m. s. type for a crest factor of 3 or less.

Note. – As a result of the different characteristics of the band elimination filters, the measurement result obtained with the SINAD meter or distortion-factor meter specified above may differ from those obtained with the measuring equipment specified in earlier editions of this standard.

6.3 *Selective measuring device*

The selective measuring device may be either a frequency selective voltmeter, a spectrum analyzer, or a calibrated field-strength meter. The bandwidth of the measuring device shall be appropriate for the measurement being made or shall be adjusted to the value stated in the method of measurement.

6.4 *Radio-frequency coupling device (RFCD)*

The measurements in this standard are applicable to receivers having either antenna terminals or an integral antenna.

Measurements of the radio-frequency parameters of receivers having an integral antenna are performed in an RFCD. When making these measurements, precautions shall be taken to ensure that:

- the receiver is adequately shielded from electromagnetic disturbance;
- the attenuation of the coupling between the radiation source and the receiver being measured is sufficiently low, stable, and constant throughout the measuring frequency range.

Note. – The coupling loss depends on the particular measuring arrangement, the frequency being used, and the receiver being measured. Normally, it is not precisely measured, as it will only be useful for a particular measuring arrangement and frequency

The coupling loss shall be sufficiently low so that the output power requirements of the signal generators used in this standard will not exceed the power output capability of commercially available signal generators.

To ensure measurement repeatability, an RFCD which includes the following should be used in the measurement arrangement:

- a radiating element;
- a radio-frequency input terminal connected to the radiating element through a transmission line;
- a means to ensure that the input impedance of the RFCD be the same as the impedance of the transmission line from the radio-frequency signal generator;

- a means for positioning the receiver being measured in a precise, repeatable and stable manner;
- a means to ensure that the presence of the person making the measurement shall not affect the results.

It shall also have the following characteristics:

- a coupling loss between the radio-frequency input terminal and the receiver being measured of less than 30 dB;
- a coupling loss variation over the frequency range used in the measurement which does not exceed 2 dB;
- no non-linear elements which can affect the accuracy of the measurement results.

6.5 *Acoustic coupling device*

See Clause F2 of Appendix F.

SECTION THREE – METHODS OF MEASUREMENT FOR RECEIVERS EQUIPPED WITH SUITABLE ANTENNA TERMINALS

7. **Reference sensitivity**

7.1 *Definition*

The level of the input signal at a specified frequency with specified modulation which will result in the standard signal-to-noise ratio (Sub-clause 3.3) at the output of the receiver.

7.2 *Method of measurement*

a) Connect the equipment as illustrated in Figure 3, page 25.

b) Apply a standard input signal (see Sub-clause 5.3) to the receiver-input terminals.

c) Adjust the receiver volume control to obtain the reference output level (see Sub-clause 3.1.2). Record this level.

d) Adjust the input-signal level to produce the standard signal-to-noise ratio. Record this level.

e) If the output level obtained in step *d)* is more than 3 dB below the level recorded in step *c)*, this fact should be recorded. The input-signal level at which the output level has fallen by 3 dB should be recorded.

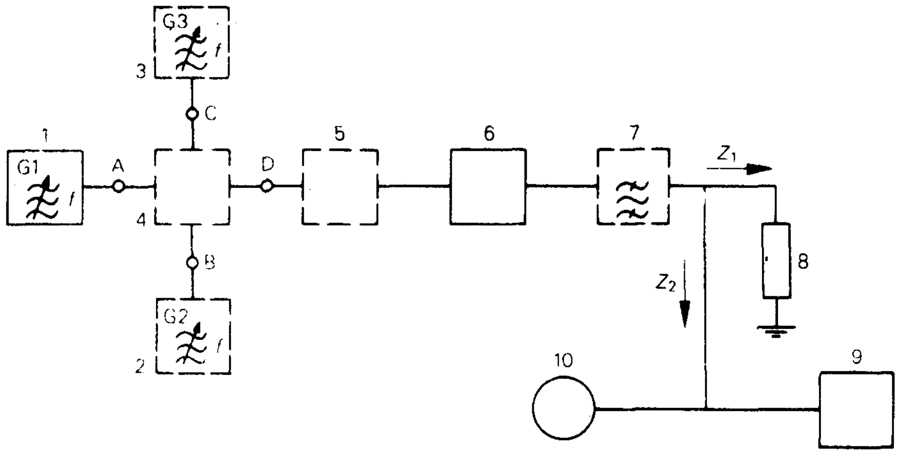
f) The reference sensitivity is the level recorded in step *d)*. It is expressed as:

The reference sensitivity for a $\frac{S+N+D}{N+D}$ ratio of 12 dB is ____ μV or dB (μV).

8. **Audio-frequency response**

8.1 *Definition*

The audio-frequency output signal level variation as a function of the sideband frequency corresponding to the audio-frequency being measured, for a constant input signal level.



1 = radio-frequency signal generator (see Sub-clause 5.3)
2 = radio-frequency signal generator, if required
3 = radio-frequency signal generator, if required
4 = matching or combining network, if required
5 = artificial antenna, if required
6 = receiver under test
7 = band-limiting filter
8 = audio-frequency load
9 = distortion factor meter
10 = audio-frequency selective measuring device

Note. – The input impedances of the distortion factor meter and the audio-frequency selective measuring device should be such that $Z_2 > Z_1$.

FIG. 3. – General arrangement for measuring receiver characteristics.

8.2 *Method of measurement*

a) Connect the equipment as illustrated in Figure 3 and connect an additional signal generator G3 to the matching or combining network (R3E, J3E).

b) Apply a standard input signal to the receiver input terminals (see Sub-clause 5.3).

c) Reduce the necessary sideband signal by 10 dB.

d) For reception modes R3E and J3E, apply a signal from the additional generator G3 at a level of 60 dB (μV) to produce an additional 1600 Hz signal at the receiver output to stabilize the gain of the receiver.

e) Adjust the receiver volume control to produce the reference output level.

f) While maintaining a constant input signal level, vary the frequency of the necessary sideband signal (*c*) over the specified range. At each test frequency, measure the level and frequency of the output signal by means of the selective measuring device. When measuring in the vicinity of 1 600 Hz, the frequency of the additional signal generator must be displaced so that the resultant pilot signal is just outside the passband of the selective measuring device. Record each audio-frequency and the corresponding output level.

g) These tests may be repeated at other necessary sideband signal levels, but care should be taken to avoid overloading in the receiver audio-output stages.

8.3 *Presentation of results*

Plot the levels recorded in Step *f)*, in decibels relative to the level at 1 000 Hz, on the linear ordinate of a graph, and the audio-frequency on the logarithmic abscissa.

9. Total distortion factor

9.1 *Definition*

The ratio, expressed as a percentage, of the r.m.s. value of a distorted signal without its fundamental component, to the r.m.s. value of the complete signal. The distorted signal includes harmonically related components, supply ripple, and non-harmonically related components.

9.2 *Method of measurement*

a) Connect the equipment as illustrated in Figure 3, page 25.

b) Apply a standard input signal to the receiver input terminals (see Sub-clause 5.3).

c) Operate the receiver at rated output level (see Sub-clause 3.1.1).

d) Measure the total distortion factor at the audio-frequency load.

Notes 1. – This method of measurement is valid for other audio-frequencies and other levels of sideband signal.

2. – The audio-frequency measuring bandwidth should be limited in accordance with Section Two.

10. Relative audio-frequency intermodulation product level

10.1 *Definition*

The ratio, expressed in decibels, of:

a) the level of an unwanted non-harmonic output-signal component caused by non-linear distortion in the receiver when receiving an input signal representing simultaneous modulation of an appropriate mode transmitter by two signals, each producing a specified level of wanted sideband,

to

b) the level of one of the wanted output signals.

10.2 *Method of measurement*

a) Connect the equipment as shown in Figure 3 and connect an additional radio-frequency signal generator G3 to terminal C of the matching and combining network.

b) In the absence of a signal from generator G3, adjust generators G1 and G2 to produce a standard input signal at the receiver.

c) Adjust the receiver volume control to produce the rated audio-frequency output level.

d) Adjust generator G3 to produce a sideband corresponding to 1 600 Hz modulation at one of the following levels at the receiver input terminals:

R3E 60 dB (μV)
H3E 54 dB (μV)
J3E 60 dB (μV)

e) With the selective measuring device, measure the level of the 1 000 Hz component and the frequency and level of each intermodulation product at the output of the receiver.

Notes 1. – The audio-frequency bandwidth should be limited in accordance with Section Two.

2. – This method can be used with sideband components producing audio-frequencies other than 1 000 Hz and 1 600 Hz.

10.3 *Presentation of results*

Calculate the ratio, in decibels, of the intermodulation product level to the wanted signal level at 1 000 Hz, both measured in Step *e)*.

Tabulate the results as follows:

Intermodulation product frequency (Hz)	Ratio (dB)

State the class of emission.

11. Squelch characteristics

This clause deals with squelch circuits operated by the presence of modulation sidebands and/or carrier.

Note. – The term "squelch" is synonymous with "mute".

11.1 *Squelch opening and closing levels*

11.1.1 *Definition*

The modulated input-signal levels at which the squelch opens and closes.

Note. – If the receiver has an adjustable squelch control, these levels will vary with the setting of this control.

11.1.2 *Method of measurement for receivers having adjustable squelch controls*

a) Connect the equipment as illustrated in Figure 3, page 25.

b) A test signal at a level of 1 mV (unless otherwise specified), and having modulation characteristics suitable for the particular squelch circuit as specified by the manufacturer, shall be used.

c) Operate the receiver at the reference output level.

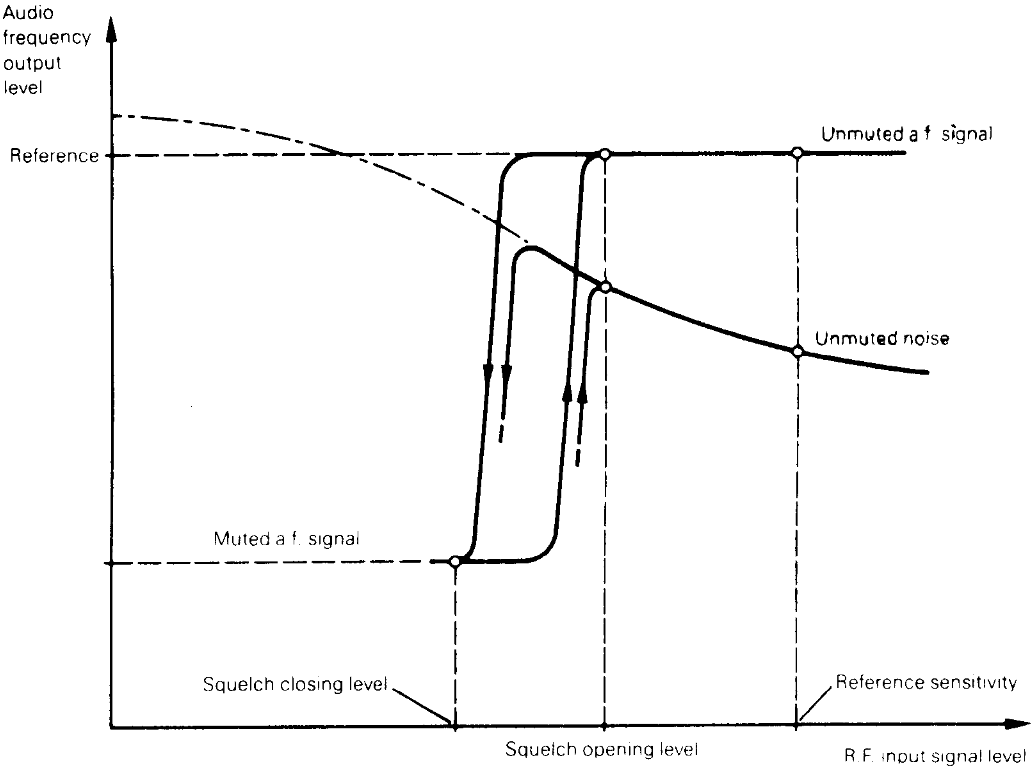
d) Reduce the input-signal level to the minimum possible. Adjust the squelch control until the squelch opens. Should it not open, adjust the squelch control to the position that requires the smallest signal to unsquelch the receiver and proceed to Step *h)*.

e) Adjust the squelch until the squelch just closes.

f) Increase the input-signal level until the squelch just opens.

g) Again reduce the input-signal level to the minimum possible and observe whether the squelch closes again. If it does not close, readjust the squelch control until the squelch just closes.

h) Increase the input-signal level until the squelch just opens and record the signal level as the minimum squelch opening level in μV or dB (μV).



Note. – The input-signal levels shown are relative and are for illustrative purposes only.

FIG. 4. – Squelch opening and closing levels.

i) Reduce the input-signal level until the squelch just closes. Record this signal as the minimum squelch closing level in μV or dB (μV).

j) Adjust the squelch control to the position that requires the largest signal to unsquelch the receiver. Adjust the input-signal level until the squelch just opens. Record this level as the maximum squelch opening level in μV or dB (μV).

k) Reduce the input-signal level until the squelch just closes. Record this signal level as the maximum squelch closing level in μV or dB (μV).

11.1.3 *Method of measurement for receivers having pre-set squelch controls*

Perform the measurement according to Steps *a), b), c), d), h)* and *i)* of Sub-clause 11.1.2 and record the signal levels obtained in Steps *h)* and *i)* as the squelch opening and closing levels, respectively.

11.2 *Squelch opening and closing delays*

11.2.1 *Definition*

The intervals between the time of occurrence of a specified increase or decrease of the level of a modulated radio-frequency input signal and the time at which the voltage across the audio-frequency load is 50% of its steady-state unsquelched value.

11.2.2 *Method of measurement*

a) Connect the equipment as illustrated in Figure 3, page 25, with:

1) an oscilloscope having a calibrated horizontal sweep connected in parallel with the audio-frequency load, and
2) an electronically-controlled, single-step attenuator having a difference of at least 30 dB between its two states, connected between the input-signal source and the receiver.

Note. – The switching time of the attenuator should be short compared with the expected squelch opening and closing times.

b) Operate the receiver with no input signal. If equipped with an adjustable squelch control, adjust it to the position where the squelch just closes (see Sub-clause 11.1.2, Step *g)*).

c) Apply the standard input signal and operate the receiver at the reference output level. Note this level on the oscilloscope.

d) With the 30 dB single-step attenuator at the maximum attenuation value, adjust the input-signal level of the receiver to a value which is approximately 6 dB below the minimum squelch closing level.

e) Derive the synchronizing pulse for the calibrated horizontal sweep of the oscilloscope from the attenuator activating signal.

f) Change the state of the step attenuator from maximum to minimum attenuation. Measure and record the interval between the time of changing the attenuation and the time at which the voltage across the audio-frequency load increases to and remains above 50% of the value noted in Step *c)*. This interval is the squelch opening delay.

g) Change the state of the step attenuator from minimum to maximum attenuation. Measure and record the interval between the time of changing the attenuation and the time at which the voltage across the audio-frequency load decreases to 50%. This interval is the squelch closing delay.

Note. – A variant of this method may be used whereby a dual trace storage oscilloscope is made to show:

on one trace, the radio-frequency signal which triggers the sweep,
and
on the other trace, the audio-frequency signal.

11.3 *Squelch blocking threshold*

Under consideration.

12. **Signal-to-residual output-power ratio**

This test is only applicable to the H3E mode.

12.1 *Definition*

The ratio, in decibels, of:

a) the reference output power

to

b) the residual output power in the absence of modulation, both measured at the standard input-signal level.

12.2 *Method of measurement*

a) Connect the equipment as illustrated in Figure 3, page 25.

b) Where possible, adjust the squelch control to the unsquelched position.

c) Apply a standard input signal to the receiver.

d) Operate the receiver at the reference output level.

e) Remove the sideband signal and record the reduction, in decibels, of the level into the audio frequency test load.

13. Impulsive noise

13.1 *General*

Impulsive noise degrades the performance of a receiver by reducing its sensitivity, for example, the input-signal level must be increased to maintain a specified signal-to-noise ratio. The response of the receiver to impulsive noise will vary with the spectrum amplitude of the noise (see Appendix C) and the noise pulse-repetition rate.

13.2 *Impulsive-noise tolerance*

13.2.1 *Definition*

The ability of a receiver to prevent impulsive noise from degrading the desired response at the output of the receiver.

It is expressed as a ratio of

a) the median level of spectrum amplitude of the impulsive noise that causes a wanted signal, which is 3 dB in excess of the reference sensitivity, to restore the standard signal-to-noise ratio at the receiver output terminals

to

b) the reference sensitivity.

13.2.2 *Method of measurement*

Notes 1. – The value of the reference sensitivity determined in Sub-clause 7.2 is required for this measurement.

2. – For information on the characteristics and calibration of a random impulse generator, see Appendix C.

a) Calibrate the random impulse generator in accordance with Appendix C, Clause C3, and record the minimum attenuation median spectrum amplitude *S* and the minimum attenuation value *M*. Increase the attenuation to a high value.

b) Connect the equipment as illustrated in Figure 3, page 25, and connect the random impulse generator to terminal C of the appropriate matching or combining network (see Appendix A).

c) In the absence of the impulsive noise, apply the standard input signal to terminals A and B of the combining network (see Sub-clause 5.3). Reduce its level to obtain reference sensitivity at the input of the receiver.

d) Increase the level of the wanted input signal by 3 dB.

e) Adjust the random-impulse generator to the following settings:

- a frequency 100 kHz below the standard input frequency,
- an average pulse repetition rate of 100 impulses per second,
- a pulse duration of 0.2 µs,
- a standard deviation of amplitude of 6 dB,
- a 10 Hz cut-off frequency of the low-pass filter,
- a minimum spectrum amplitude.

Note. – The random-impulse generator settings simulate the noise produced by city traffic that would impinge on the antenna of a nearby land mobile station. The above settings of the random impulse generator are not applicable to other environments.

f) Adjust the attenuator of the random impulse generator until the standard signal-to-noise ratio at the receiver output terminals is obtained. Record the attenuation A in decibels.

13.2.3 *Presentation of results*

a) The impulse noise tolerance is:

$$S - A + M - B - E \ \text{dB} \left[\frac{\mu\text{V/MHz}}{\mu\text{V}} \right]$$

where:

S is the minimum attenuation median spectrum amplitude recorded in Step *a)* of Sub-clause 13.2.2

A is the attenuation value recorded in Step *f)* of Sub-clause 13.2.2

M is the minimum attenuation value recorded in Step *a)* of Sub-clause 13.2.2

B is the loss of the combining network (3) in decibels

E is the reference sensitivity in dB (μV)

b) Record the impulsive-noise tolerance, the standard input signal frequency, the reference sensitivity and the settings of the random impulse generator.

14. Selectivity

14.1 *General*

Selectivity is the ability of the receiver to discriminate between wanted and unwanted input signals. It can be evaluated by measuring the adjacent-signal selectivity, the spurious response, crossmodulation and blocking or desensitization.

The methods of measurement described in this clause deal only with interference that degrades the wanted receiver output signal due to the simultaneous presence of an unwanted input signal. It is to be noted, however, that unwanted signals may also be objectionable when the wanted signal is not present.

Note. – It is important that the signal generators used in the following measurements be free of spurious emissions. If spurious emissions do exist, notch filters should be used to eliminate them.

14.2 *Adjacent-signal selectivity (including blocking)*

14.2.1 *Definition*

The ratio of

a) the level of an unwanted input signal that reduces the signal-to-noise ratio, produced by a signal 3 dB in excess of the reference sensitivity, to the standard signal-to-noise ratio

to

b) the reference sensitivity.

Blocking is a particular case of adjacent-signal selectivity where the difference between the unwanted signal frequency and the standard input-signal frequency is a specified amount greater than 1% of the standard input-signal frequency.

14.2.2 *Method of measurement*

Note. – This measurement requires knowledge of the reference sensitivity (see Clause 7).

a) Connect the equipment as illustrated in Figure 3, page 25, and connect an additional signal generator (unwanted signal source) to terminal C of the appropriate matching or combining network (see Appendix A).

b) In the absence of the unwanted signal, apply the standard input signal (see Sub-clause 5.3) to the receiver. Reduce its level to obtain the reference sensitivity at the input of the receiver. Record this level in μV or dB (μV).

c) Increase the level of the wanted input signal by 3 dB.

d) Apply an unwanted, unmodulated input signal to terminal C of the matching or combining network.

e) Adjust the unwanted signal frequency by a specified amount above and below the wanted carrier frequency outside the passband of the receiver. At each frequency adjust the unwanted level so as to re-establish the standard signal-to-noise ratio. Record the level of the unwanted signals in μV or dB (μV).

f) Calculate the ratios, in decibels, of the unwanted signal levels measured in Step *e)* to the reference sensitivity.

The smaller value is the adjacent-signal selectivity.

g) Steps *e)* and *f)* may be repeated for other values of frequency displacement.

Note. – The results may be displayed in a table.

14.2.3 *Adjacent channel selectivity*

Where mobile radio services use discrete channel spacings, the value of adjacent-signal selectivity, measured with a signal spacing equal to the discrete channel spacing, may be quoted as the value of the adjacent-channel selectivity, for a given frequency spacing of the channels.

14.3 *Crossmodulation*

14.3.1 *Definition*

The amplitude modulation of the wanted signal, within the receiver, by the modulation of an unwanted signal.

14.3.2 *Method of measurement*

a) Connect the equipment as illustrated in Figure 3 and connect an additional signal generator (unwanted signal source) to terminal C of the appropriate matching or combining network (see Appendix A).

b) In the absence of the unwanted signal, apply a standard input signal (see Sub-clause 5.3).

c) Adjust the receiver volume control to produce the reference output level.

d) Apply an unwanted signal 30% amplitude modulated with 400 Hz to the combining network and adjust the unwanted input signal to a frequency approximately 30 kHz above or below the standard input-signal frequency.

Note. – For receivers in which the adjacent-signal selectivity at 30 kHz would affect the results, greater frequency separation should be used.

e) Increase the unwanted input-signal until the SINAD at the receiver output is reduced to 20 dB due to crossmodulation.

Note. – To test that the observed effect is crossmodulation, remove the wanted signal and verify that the unwanted audio-frequency signal disappears from the receiver output terminals.

f) The input level of the unwanted signal, in decibels relative to 1 μV, at which the condition in Step *e)* is obtained, is a measure of the crossmodulation immunity.

14.4 *Spurious-response immunity*

14.4.1 *Definition*

The ability of the receiver to prevent single unwanted signals from causing an unwanted response at the output of the receiver.

It is expressed as the ratio, in decibels, of:

a) the level of a single unwanted signal that reduces the signal-to-noise ratio, produced by a wanted signal 3 dB in excess of the reference sensitivity, to the standard signal-to-noise ratio

to

b) the reference sensitivity.

14.4.2 *Method of measurement*

Note. – This measurement requires knowledge of the reference sensitivity (see Clause 7).

a) Connect the equipment as illustrated in Figure 3, page 25, and connect an additional signal generator (unwanted signal source) to terminal C of the appropriate matching or combining network (see Appendix A).

b) In the absence of the unwanted signal, apply the standard input signal (see Sub-clause 5.3) to the receiver. Reduce its level to obtain the reference sensitivity at the input of the receiver. Record this wanted signal level in μV or dB (μV).

c) Increase the level of the wanted input signal by 3 dB.

d) Apply a high-level, unwanted, unmodulated input signal [for example, 90 dB (μV)] to terminal C of the combining network.

e) Vary the unwanted input-signal frequency over a specified frequency range to search for degradation of the signal-to-noise ratio. When a response is found, carefully adjust the frequency of the unwanted signal to maximize the degradation.

f) At the frequency of each spurious response, change the level of the unwanted input signal until the standard signal-to-noise ratio is obtained at the receiver output terminals. Record the frequency of the unwanted input signal and record its level at the input of the receiver in μV or dB (μV).

g) Calculate the ratios, in decibels, of the unwanted signal levels recorded in Step *f)* to the reference sensitivity. This ratio is the spurious-response immunity for the frequency concerned.

14.4.3 *Presentation of results*

Tabulate the ratios obtained in Step *g)* together with the frequencies recorded in Step *f)*. Record the nominal operating frequency.

14.5 *Intermodulation immunity*

14.5.1 *Definition*

The ability of the receiver to prevent two unwanted signals, with a specific frequency relationship to the wanted-signal frequency, from causing an unwanted response at the output of the receiver due to intermodulation.

It is expressed as the ratio, in decibels, of

a) the level of two equal-level unwanted signals that reduce the signal-to-noise ratio, produced by a wanted signal 3 dB in excess of the reference sensitivity, to the standard signal-to-noise ratio to

b) the reference sensitivity.

Note. – Refer to Appendix D for frequency relationships likely to result in an unwanted response due to intermodulation.

14.5.2 *Method of measurement*

Note. – This measurement requires knowledge of the reference sensitivity (see Clause 7).

a) Connect the equipment as illustrated in Figure 3, page 25, and connect two additional signal generators (unwanted signal sources) to an appropriate matching or combining network (see Appendix A for examples of combining networks).

b) In the absence of unwanted signals, apply the standard input signal (see Sub-clause 5.3) to the receiver and reduce its level to obtain the reference sensitivity at the input of the receiver. Record this level in µV or dB (µV).

c) Increase the level of the wanted input signal by 3 dB.

d) Apply an unwanted, unmodulated input signal adjusted to a specified frequency f_n.

e) Apply an unwanted, unmodulated input signal adjusted to a specified frequency f_t.

f) Incrementally increase the levels of the two unwanted signals until the wanted signal-to-noise ratio is degraded.

g) Carefully adjust the frequency of one of the unwanted signals to maximize the degradation.

h) Adjust the levels of the unwanted signals to be equal at the receiver input and to produce the standard signal-to-noise ratio at the receiver output. Record this level in µV or dB (µV).

i) Calculate the ratio, in decibels, of the level recorded in Step *h)* to the reference sensitivity. This ratio is the intermodulation immunity for the frequencies concerned.

Note. – Measuring errors may result from intermodulation between generators, generator noise, or receiver desensitization. See Appendix B for precautions regarding the signal generators.

15. Automatic gain control (A.G.C.) characteristics

15.1 *Definition*

The change in output level as a function of the level of the input signal.

15.2 *Method of measurement*

a) Connect the equipment as illustrated in Figure 3 and connect an additional signal generator G3 to the matching or combining network.

Note. – The additional generator is used in mode J3E to control the gain. The gain variation is determined by measuring the level of the necessary sideband.

b) Apply a standard input signal to the receiver input terminals and increase the level by 40 dB.

c) Reduce the level of the necessary sideband by 10 dB.

d) For reception mode J3E, apply a signal from the additional generator at a level of 100 dB (µV) to produce an additional 1 600 Hz signal at the receiver output terminals at a level 10 dB greater than 1 000 Hz audio-frequency signal.

e) Adjust the receiver volume control to provide the reference output level.

f) Reduce the composite-signal level in steps and record the 1000 Hz audio-frequency output-level for each value of the composite-signal level. Continue until the reference sensitivity is reached.

g) The measurement may be continued at lower input-signal levels to determine the performance at levels below the reference sensitivity.

h) The measurement may also be extended to levels above 100 dB (μV) to identify the upper limit of the A. G. C. characteristic.

15.3 *Presentation of results*

Plot the level of the output (1000 Hz) relative to the reference output level, in decibels, on the linear ordinate of a graph, and the input signal level, in dB (μV), on the linear abscissa. Record the reference output level.

Alternatively, a table of values may be presented.

15.4 *Dynamic automatic gain-control characteristic*

15.4.1 *General*

The dynamic automatic gain-control characteristic is the transient effect upon the level of the output signal caused by a sudden change of the input-signal level. It is defined in terms of its attack and recovery times.

15.4.2 *Definition – A. G. C. attack time*

The elapsed time from the instant at which the input-signal level is suddenly increased by a specified amount until the instant at which the level of the output signal reaches and remains within ±2 dB of the subsequent steady-state value.

15.4.3 *Method of measurement*

a) Connect the equipment as illustrated in Figure 3, page 25, and connect an oscilloscope in parallel with the audio-frequency test load. Connect an electronically-controlled attenuator capable of providing a specified change in input-signal level, for example 20 dB, between the r. f. signal source and the receiver input terminals.

b) Set the attenuator to maximum attenuation.

c) Apply the standard input signal (see Sub-clause 5.3) and reduce its level to reference sensitivity.

d) A receiver equipped with an accessible volume control is to be adjusted to provide a level of at least 20 dB below the rated output level.

e) Synchronize the calibrated horizontal sweep of the oscilloscope with the attenuator-actuating signal.

f) Actuate the attenuator.

g) Measure and record the interval between the instant of actuating the attenuator and the instant after which the 1000 Hz output signal reaches and remains within ±2 dB of the subsequent steady-state level (Points A and B in Figure 5, page 47). This interval is the A. G. C. attack time.

Note. – A variation of this method is to use a dual-trace storage oscilloscope to show:
on one trace, the radio-frequency signal, and
on the other trace, the audio-frequency signal.

15.4.4 *Definition – A. G. C. recovery time*

The elapsed time from the instant when the input-signal level is suddenly decreased by a specified amount until the instant at which the output signal reaches and remains within ±2 dB of the subsequent steady-state value.

15.4.5 *Method of measurement*

a) Carry out Steps *a)* to *f)* in Sub-clause 15.4.3, except that the input-signal level should be decreased, for example, by 20 dB, at the moment of change. The radio-frequency input-signal level initially applied should be approximately 20 dB greater than the reference sensitivity.

b) Measure and record the interval between the instant of actuating the attenuator and the instant after which the 1000 Hz output signal reaches and remains within ±2 dB of the subsequent steady-state level (Points C and D in Figure 5). This interval is the A. G. C. recovery time.

Note. – A variant of this method is to use a dual trace storage oscilloscope to show:
on one trace, the radio-frequency signal, and
on the other trace, the audio-frequency signal.

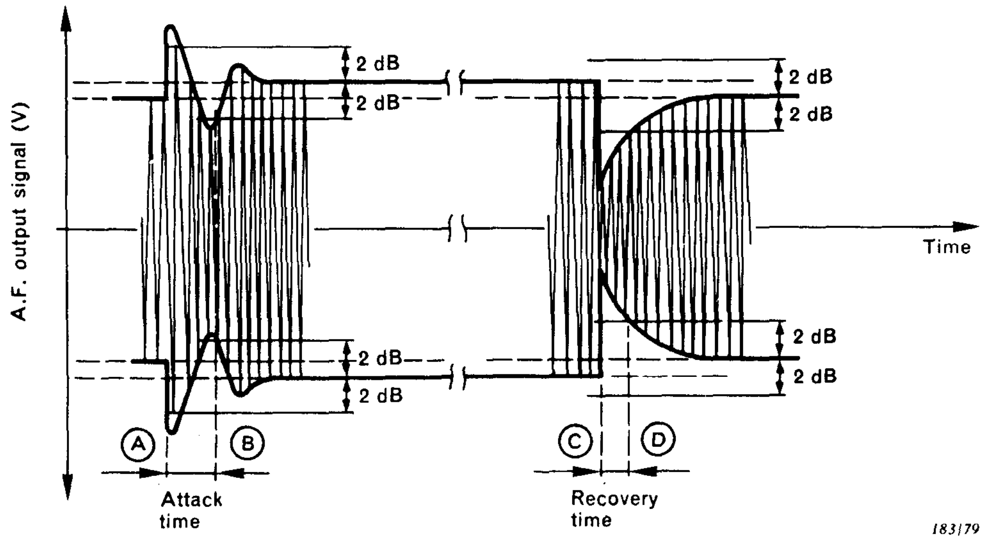


Fig. 5. – Example of dynamic A. G. C. characteristic.

16. Radiated spurious emission

Under consideration.

17. Conducted spurious components

17.1 *Definition*

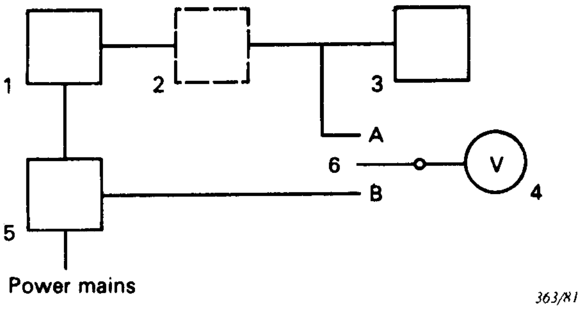
Conducted spurious components are radio-frequency components that are usually characterized by having a dominant component at a discrete frequency or in a narrow band of frequencies. They may be present at the antenna or a. c. power terminals of the receiver.

17.2 *Method of measurement of antenna terminal conducted spurious components*

a) Connect the equipment as shown in Figure 6.

b) With the receiver operating, adjust the frequency of the selective measuring device (4) over the specified range of measurement to search for the spurious components.

c) Record the frequency and level of each spurious component found.



1 = receiver under test
2 = artificial antenna, if required (see Sub-clause 5.1.2)
3 = test load
4 = selective measuring device
5 = mains power line impedance stabilization (isolation) network
6 = switch

FIG. 6. – Measurement arrangements for antenna terminals and a. c. power terminal conducted spurious components.

Notes 1. – For the purpose of this measurement, the impedance of the test load (3), including the effect of the selective measuring device (4), should be equal to the source impedance required by the artificial antenna (or the receiver).

2. – Measurement precautions: Precautions should be taken to prevent interfering voltages from entering the measuring equipment, either by radiation or through the mains supply leads.

3. – This test method is limited to the case of metre and decimetre wavelengths since voltage measured across a test load connected to the antenna terminals is not representative of the interference in the case of hectometre waves. In the case of a ship, the result obtained when the installation is built depends to a considerable extent on the position of the antenna with respect to the superstructure.

17.3 *Presentation of results*

The levels recorded in Sub-clause 17.2, Step *c)*, expressed as a voltage or as a power, are the antenna terminal conducted spurious components. Record their frequency and the impedance of the test load. Record the component values of the artificial antenna and of the test load. Also record the characteristic impedance, and the length of the cable between the receiver and the artificial antenna.

17.4 *Method of measurement of a. c. power terminal conducted spurious components (for frequencies below 30 MHz)*

a) The asymmetrical components are measured using the arrangement shown in Figure 6, page 49, but with switch (6) in position B.

Note. – An example of a mains power line impedance stabilization (isolation) network, also known as an artificial mains network, is given in Appendix E.

b) With the receiver operating, adjust the frequency of the selective measuring device (4) over the specified range of measurement to search for spurious components.

c) Record the frequency and level of each spurious component found, along with the attenuation due to the mains power stabilization (isolation) network.

17.5 *Presentation of results*

The levels recorded in Sub-clause 17.4, Step *c)*, corrected for the loss of the mains power line impedance stabilization (isolation) network and expressed as a voltage or as a power, are the a. c. power terminal conducted spurious components.

17.6 *Method of measurement at the a. c. power terminal (for frequencies up to 1 000 MHz)*

No requirement at this time.

18. Evaluation of the receiving part of the equipment under duplex conditions

18.1 *General*

The characteristics to be measured should be agreed upon and should be measured in accordance with this standard. The presence of the transmitter radio-frequency power may cause additional spurious responses and a desensitization of the receiver.

18.2 *Measurement procedure*

The measurement should be made under standard test conditions using the arrangement shown in Figure 2, page 17.

The characteristics should be measured with the transmitter in both the standby and the transmit conditions.

When the transmitting and the receiving parts operate on separate antennas, the tests may be repeated for specified radio-frequency attenuation between the transmitter output and the receiver output.

19. Receiver performance under conditions deviating from standard test conditions

The performance of the receiver can be evaluated under conditions deviating from standard test conditions.

The performance characteristics and the environmental conditions at which the measurements are to be made shall be those explicitly specified in the equipment specification. The results obtained can be compared with those obtained under standard test conditions.

Some performance characteristics may reach a maximum degradation at some intermediate environmental conditions and not necessarily at the extreme.

19.1 *Initial measurements under standard test conditions*

Before beginning the tests described in the following sub-clauses, the relevant performance characteristics should first be measured under standard test conditions in accordance with the methods specified in this section.

Unless otherwise stated, the measurements should be made after a one hour equipment warm-up.

With a standard input signal applied to the receiver input terminals, the volume control, if available, should be adjusted for the reference output level.

No readjustment of the receiver shall be made during the following tests, except for a proper execution of the measurements.

19.2 *Variation of primary power supply*

The measurement shall be made in accordance with the provisions of Clause 27 of IEC Publication 489-1.

19.3 *Variation of ambient temperature*

The measurement shall be made under the environmental conditions specified in Clause 28 of IEC Publication 489-1, with the following additional requirements.

19.3.1 *Cold*

After the equipment has been switched on, the required characteristic shall be measured after a maximum warm-up period of 15 min, unless otherwise specified.

19.3.2 *Dry heat*

The measurements shall be made after completion of the appropriate duty cycle (see IEC Publication 489-1, Section Six).

19.4 *Variation of humidity*

The required characteristics shall be measured under the environmental conditions specified in Clause 29 of IEC Publication 489-1.

After the equipment has been switched on, the measurements shall be made after a one hour warm-up period unless otherwise specified.

19.5 *Vibration*

For equipment intended to have immunity to vibration, the required characteristics shall be measured after the vibration test has been performed in conformity with Sub-clause 30.1 of IEC Publication 489-1.

19.6 *Shock*

For equipment intended to have immunity to shock, the required characteristics shall be measured after the shock test has been performed in conformity with Sub-clause 30.2 of IEC Publication 489-1.

19.7 *Drop (free fall)*

For personal equipment intended to have immunity to damage from drops, the required characteristics shall be measured after the drop test has been performed in conformity with Sub-clause 30.3 of IEC Publication 489-1.

19.8 *Dust and sand*

For equipment intended to have immunity to dust and sand, the required characteristics shall be measured after the dust and sand test has been performed in conformity with Sub-clause 30.4 of IEC Publication 489-1.

19.9 *Driving rain*

For equipment intended to have immunity to driving rain, the required characteristics shall be measured after the driving rain test has been performed in conformity with Sub-clause 30.5 of IEC Publication 489-1.

19.10 *Corrosion (salt fog)*

For equipment intended to have immunity to corrosion (salt fog), the required characteristics shall be measured after the corrosion test has been performed in conformity with Sub-clause 30.6 of IEC Publication 489-1.

SECTION FOUR – METHODS OF MEASUREMENT FOR RECEIVERS WITH INTEGRAL ANTENNAS

MEASURING ARRANGEMENTS

Receivers having integral antennas or having no facilities for connecting the external measuring equipment require special measuring arrangements.

Deviations from standard atmospheric conditions may be necessary for measurements made out of doors. The actual conditions should be stated in the test report.

20. **Reference (radiation) sensitivity**

20.1 *Definition*

The minimum field strength of a signal at a specified frequency with specified modulation which will produce the standard signal-to-noise ratio at the output of the receiver.

20.2 *Measuring arrangement*

Receivers having an integral antenna or having no facility for connecting the external measuring equipment require special measuring arrangements.

A typical arrangement using a 30 m test site is described in Appendix G.

Deviations from standard atmospheric conditions may occur for measurements made out-of-doors. The actual conditions, however, should not cause the measuring results to deviate appreciably from those which have been obtained under standard test conditions.

Wherever possible, direct connection to the audio terminals of the receiver should be made, provided that the results of the measurement are not affected (see Appendix F, Clause F1).

Note. – When direct connections are not possible, the use of an acoustic coupling device is recommended (see Appendix F, Clause F2).

20.3 *Method of measurement for equipment fitted with squelch circuits*

a) Connect the equipment as illustrated in Figure G1*a* of Appendix G, page 128, and calibrate the test site.

b) Apply a standard input signal to the transmitting antenna (3) (see Sub-clause 5.3).

c) Increase the level by 40 dB. Ensure that the receiver squelch is opened. Adjust the input signal level to obtain the standard signal-to-noise ratio. If necessary, readjust the squelch to be open at this input level. Record this level in µV.

d) Orientate the equipment so that a face, specified by the manufacturer, is normal to the direction of the transmitting antenna (3). This orientation is the reference for the measurement of the azimuth.

e) In the case of an adjustable squelch, adjust it to open using an input signal level which provides a signal-to-noise ratio between 10 and 20 dB, as estimated by a listening test. Retain this squelch setting in the following measuring procedure up to Step *l)*.

f) Reduce the level of the radio-frequency signal generator (2) to close the squelch. Then increase the level until the squelch just opens, and record this level in µV.

g) Rotate the equipment under test successively in seven (7) steps of 45° and record the levels of the radio-frequency signal generator (2) required to just open the squelch at each of the azimuth positions.

h) Make a table of results and, if desired, plot them as points on a polar diagram.

i) If the results indicate that at a particular azimuth angle the radio-frequency signal generator output level is significantly less than at other angles, determine the minimum radio-frequency signal generator level required to open the squelch, by proceeding as follows:

In the vicinity of the assumed azimuth for the minimum r.f. level, select smaller azimuth rotation angles, for example 15°, and for each azimuthal position, determine the level of the radio-frequency signal generator (2) to obtain the standard signal-to-noise ratio. Record the lowest level.

j) By the method given in Appendix G, Sub-clause G8.5, calculate the actual field strength in µV/m around the equipment under test on the test site using the radio-frequency signal generator level recorded in Step *i)*.

k) Transfer the equipment to a radio-frequency coupling device (RFCD) supplied by or specified by the manufacturer in accordance with other provisions of this standard. Apply a standard input signal (see Sub-clause 5.3) to the RFCD, and adjust the level to just open the squelch. Record this level in µV.

l) Adjust the input signal level to obtain the standard signal-to-noise ratio. If necessary re-adjust the squelch to be just open at this input level. Record this level in µV.

m) Calculate and record the ratio of the levels recorded in Steps *k)* and *l)*.

n) Multiply the level determined in Step *j)* by the ratio recorded in Step *m)* to obtain the minimum field strength needed to produce the standard signal-to-noise ratio. Record this field strength as the reference radiation sensitivity.

20.4 *Method of measurement for equipment not fitted with squelch circuits*

a) Connect the equipment as illustrated in Figure G1*a*, page 128, and described in Appendix G and calibrate the test site.

Where acoustic measurements are made, the receiver shall be mounted in an acoustic coupling device, as supplied or specified by the manufacturer, in accordance with the requirements of Sub-clause 22.3.

b) Connect the equipment as illustrated in Figure G1*b* of Appendix G, page 128.

c) Apply a standard input signal to the transmitter antenna (3), and increase the level by 40 dB (see Sub-clause 5.3).

d) Orientate the equipment so that a face, specified by the manufacturer, is normal to the direction of the transmitting antenna (3). This orientation is the reference for the measurement of the azimuth.

e) Adjust the receiver volume control to obtain the reference output level.

f) Adjust the input level until the standard signal-to-noise ratio (or its acoustic equivalent) is obtained. Record this level in μV.

g) Rotate the equipment under test successively in seven (7) steps of 45° and record the corresponding levels of the radio-frequency signal generator (2) required to obtain the standard signal-to-noise ratio.

h) Make a table of results and, if desired, plot them as points on a polar diagram.

i) If the results indicate that at a particular azimuth angle, the radio-frequency signal generator output level is significantly less than at other angles, determine the radio-frequency signal generator level required to obtain the standard signal-to-noise ratio (or its acoustic equivalent), by proceeding as follows:

> In the vicinity of the assumed azimuth for the minimum r. f. level, select smaller azimuthal rotation angles, for example 15°, and for each azimuthal position, determine the level of the radio-frequency signal generator (2) to obtain the standard signal-to-noise ratio. Record the lowest level.

j) By the method given in Appendix G, Sub-clause G8.5, calculate the actual field strength in μV/m around the equipment under test on the test site using the radio-frequency signal generator level recorded in Step *i)*.

21. Average radiation sensitivity

21.1 *Definition*

The average of eight measurements of field strength at a specified frequency with specified modulation which produces the standard signal-to-noise ratio at the output of the receiver under test when the receiver is rotated in 45° increments starting at the reference azimuth.

21.2 *Method of measurement*

For equipment fitted with squelch circuits, perform Steps *a)* to *h)* and *k)* to *m)* of Sub-clause 20.3.

For equipment not fitted with squelch circuits, perform Steps *a)* to *g)* of Sub-clause 20.4.

21.3 *Presentation of results*

a) Calculate the average of the eight (8) levels, expressed in μV, recorded in Steps *g)* and *h)* of Sub-clause 20.3 or Steps *f)* and *g)* of Sub-clause 20.4. Record this value. For equipment fitted with squelch circuits, multiply this value by the ratio determined in Step *m)* of Sub-clause 20.3.

b) Calculate and record the corresponding field strength in μV/m using the ratio determined in Sub-clause G8.5 of Appendix G. This field strength is the average radiation sensitivity.

c) State whether an acoustic or electrical measurement method was used.

22. Remarks on measurements requiring the use of a coupling device (radio-frequency and/or acoustic)

22.1 *General*

The measurements described in Clauses 23 to 30 are applicable to receivers having an integral antenna. This includes receivers having:

a) audio-frequency terminals (see Figure 7*a*, page 84) or

b) an integral output transducer to which connections can be made (see Figure 7*b*, page 84) or

c) an integral output transducer where direct connection is impossible (see Figure 7*c*, page 84), except in the case of Clauses 24, 25 and 26. Where it is possible, direct electrical connection to the output transducer shall be used, providing that this does not affect the results of the measurement.

It is intended that these measurements should provide the same results for the value of the radio-frequency parameters as would be obtained if there were accessible radio-frequency input and/or audio-frequency output terminals on the receiver. In order to obtain reproducible results, the measuring arrangement should include a coupling device (radio-frequency and/or acoustic) appropriate to the type of receiver being measured (see Appendix F).

However, for Step *c)* above, it is not intended that measurements be made of audio-frequency response, harmonic distortion, or audio intermodulation distortion.

The error in the measurement of absolute quantities may reach 5 dB. The accuracy of ratio-measurements is similar to that obtained when electrical connections are used.

22.2 *Remarks on radio-frequency coupling device measurements*

These measurements require a means to couple the radio-frequency test signal to the receiver. In this standard this means will be referred to as a radio-frequency coupling device (RFCD) which will be used in the measuring arrangement. The RFCD may be a radio-frequency test fixture or a specific configuration of striplines or waveguides.

In making these measurements, attention should be directed to:

- ensuring that extraneous electromagnetic fields do not affect the accuracy of the test results;
- minimizing the coupling loss (for example, less than 30 dB) between the receiver being measured and the radiation source;

Note. – The coupling loss depends on the particular measurement arrangement, the frequency being used, and the equipment being measured. Normally the coupling loss is not precisely measured since it will only be useful for a particular measurement arrangement and frequency. By minimizing the coupling loss, the output requirement of the signal generators used in this Section will not be greater than the output of commercially available signal generators.

- having a constant coupling loss over the frequency range required by the measurement;
- ensuring the stability of the coupling loss.

In order to obtain reproducible results, the measuring arrangement should include a radio-frequency coupling device (RFCD) appropriate for the type of receiver under test. This RFCD should have the following features:

- a radiating element,

- a radio-frequency input terminal and transmission line connected to the radiating element,
- a means for precise, repeatable and stable positioning of the receiver being measured,
- a means to ensure that the presence of the person making the measurement does not affect the test results.

In addition, it shall have the following characteristics:

- a coupling loss between the radio-frequency input terminal and the receiver being measured of less than 30 dB,
- a variation of the coupling loss over the frequency range used in the measurement which does not exceed 2 dB,
- an absence of non-linear elements which can affect the accuracy of the measurement results (for example, metal core transformers),
- a V. S. W. R. of less than 1.5 over the frequency range of the measurement.

22.3 *Acoustic coupling requirements (see Appendix F, Clause F2)*

Where measurements are made using acoustic coupling, the results of the radio-frequency measurements should be the same as those obtained using a direct electrical connection to the audio output transducer. The following characteristics for an acoustic coupling device are required to ensure reproducible results:

- a means for precise, repeatable and stable positioning of the receiver being measured,
- a means to ensure that the presence of the person making the measurement and the test equipment do not affect the accuracy of the test results (particularly on a test site),
- a means for precise positioning of the acoustic coupling device in relation to the audio output transducer of the receiver being measured,
- a means to correct for deficiencies arising from the use of acoustic coupling instead of direct electrical connection (this may be a correcting network or a calibration procedure),
- a means of protection against effects of the acoustical noise environment.

23. Reference sensitivity (RFCD)

23.1 *General*

The reference sensitivity (RFCD) is not a characteristic of the receiver, but of the overall combination of the receiver and the testing arrangement. This characteristic, which is used in various tests, does not need to be measured for every test carried out on the same type of apparatus, provided that the stability of the components of the measuring arrangement, and particularly of the RFCD appropriate for the particular type of apparatus, is adequate.

23.2 *Definition*

The input signal level to the matching or combining network at standard input signal frequency and with standard modulation that produces the standard signal-to-noise ratio at the output of the receiver.

Note. – The value of the input signal level obtained in the measurement should be identical to that obtained in Step *l)* of Sub-clause 20.3 if the measurement arrangement is identical.

23.3 *Method of measurement*

a) Connect the equipment as illustrated in Figure 7, page 84.

b) Apply a standard input signal to the RFCD (see Sub-clause 5.3).

c) Readjust the receiver volume control to obtain reference output level (see Sub-clause 3.1.2). Record this level.

d) Adjust the input-signal level to produce the standard signal-to-noise ratio. Record this level.

e) If the output power obtained in Step *d)* is more than 3 dB below the level recorded in Step *c),* this fact should be recorded. The input-signal level at which the output level has fallen by 3 dB should also be recorded.

f) The reference sensitivity (RFCD) is the level recorded in Step *d).* It is expressed as follows:

The reference sensitivity (RFCD) for a standard signal-to-noise ratio of 12 dB is ____ µV or dB (µV).

24. Audio-frequency response (RFCD)

Note. – This measurement does not apply to equipment having an integral output transducer where direct connections are not possible.

24.1 *Definition*

The audio-output level variation as a function of the sideband frequency corresponding to the audio-frequency being measured, for a constant input-signal level.

24.2 *Method of measurement*

a) Connect the equipment as illustrated in Figure 7*a* or 7*b*, page 84, and connect an additional generator (G3) to the matching or combining network for classes of emissions R3E and J3E.

b) Apply a standard input signal to the input of the RFCD (see Sub-clause 5.3) and adjust the level to be 60 dB greater than that which produces the standard signal-to-noise ratio.

Note. – When direct electrical connections are made, the equipment should be set up as described in Clause F1 of Appendix F. When acoustic measurements are made, the equipment should be set up as described in Clause F2 and Figures F1 and F2, pages 120 and 121, of Appendix F.

c) Reduce the necessary sideband signal by 10 dB. Note this level.

d) For classes of emission R3E and J3E, apply a signal from the additional signal generator (G3) at a level 10 dB above that noted in Step *c),* to produce an additional 1 600 Hz signal at the receiver output to stabilize the gain of the receiver.

e) Operate the receiver at reference output level.

f) While maintaining a constant input-signal level, vary the frequency of the necessary sideband signal (Step *c)*) over the specified frequency range. At each test frequency, measure the level and frequency of the output signal by means of the selective measuring device. When measuring in the vicinity of 1 600 Hz, the frequency of the additional signal generator must be displaced so that the resultant pilot signal is just outside the passband of selective measuring device. Record each audio-frequency and the corresponding output level.

Note. – These measurements may be repeated at other necessary sideband-signal levels, but care should be taken to avoid overloading the receiver audio-output stages.

24.3 *Presentation of results*

Plot the levels recorded in Step *f)*, in decibels relative to the level at 1 000 Hz on the linear ordinate of a graph, and audio-frequency on the logarithmic abscissa.

25. Total distortion factor

Note. – This measurement does not apply to equipment having an integral output transducer where direct connections are not possible.

25.1 *Definition*

The ratio, expressed as a percentage, of the r.m.s. value of a distorted signal without its fundamental component, to the r.m.s. value of the complete signal. The distorted signal includes harmonically related components, supply ripple and non-harmonically related components.

25.2 *Method of measurement*

a) Connect the equipment as illustrated in Figure 7*a* or 7*b*, page 84.

b) Apply a standard input signal to the input of the RFCD (see Sub-clause 5.3) and adjust the level to be 60 dB greater than that which produces the standard signal-to-noise ratio.

c) Operate the receiver at the rated output level.

d) Measure the total distortion factor.

Notes 1. – This method of measurement is valid for other audio-frequencies and other levels of sideband signal.

2. – The audio-frequency measuring bandwidth should be limited in accordance with Section Two.

26. Relative audio-frequency intermodulation product level

Note. – This measurement does not apply to equipment having an integral output transducer where direct connections are not possible.

26.1 *Definition*

The ratio, expressed in decibels, of:

a) the level of an unwanted non-harmonic output-signal component caused by non-linear distortion in the receiver when receiving an input signal representing the simultaneous modulation, for the appropriate class of emission, by two signals, each producing a specified level of wanted sideband,

to

b) the level of one of the wanted output signals.

26.2 *Method of measurement*

a) Connect the equipment as illustrated in Figure 7*a* or 7*b*, page 84, and connect an additional generator (G3) to the matching and combining network.

b) Apply a standard input signal to the input of the RFCD (see Sub-clause 5.3) and adjust the level to be 60 dB greater than that which produces the standard signal-to-noise ratio.

c) Operate the receiver at the rated output level.

d) Adjust generator (G3) to produce a sideband corresponding to 1 600 Hz modulation at the same level as that of the necessary sideband (1 000 Hz).

e) With the selective measuring device, measure the level of the 1 000 Hz component and the frequency and level of each intermodulation product at the output of the receiver.

Notes 1. – The audio-frequency bandwidth should be limited in accordance with Section Two.

2. – The method can be used with sideband components producing audio-frequencies other than 1 000 Hz and 1 600 Hz.

26.3 *Presentation of results*

Calculate the ratio, in decibels, of the intermodulation product level to the wanted signal level at 1 000 Hz, both measured in Step *e)*. Tabulate the results as follows:

Intermodulation product frequency (Hz)	Ratio (dB)

State the class of emission.

27. **Squelch characteristics**

This clause deals with squelch circuits operated by the presence of modulation sidebands and/or carrier.

Note. – The term "squelch" is synonymous with "mute".

27.1 *Squelch opening and closing levels*

27.1.1 *Definition*

The modulated input-signal levels, expressed as a field strength at which the squelch opens and closes.

Note. – If the receiver has an adjustable squelch control, these levels will vary with the setting of this control.

27.1.2 *Method of measurement for receivers having adjustable squelch controls*

Note. – This measurement requires that the reference radiation sensitivity be known (see Clause 20).

a) Connect the equipment as illustrated in Figure 7.

b) Apply a standard input signal to the input of the matching or combining network (see Sub-clause 5.3).

c) Operate the receiver at the reference output level.

d) Adjust the input-signal level to produce the standard signal-to-noise ratio. Record the level in μV or dB (μV).

e) Reduce the input-signal level to the minimum possible. Adjust the squelch control until the squelch opens. Should it not open, adjust the squelch control to the position that requires the smallest signal to unsquelch the receiver and proceed to Step *i)*.

f) Adjust the squelch control until the squelch just closes.

g) Increase the input-signal level until the squelch just opens.

h) Again reduce the input signal level to the minimum possible and observe whether the squelch closes again. If it does not close, readjust the squelch control until the squelch just closes.

i) Increase the input signal level until the squelch just opens and record the signal level in µV or dB (µV).

j) Reduce the input signal level until the squelch just closes and record the signal level in µV or dB (µV).

k) Adjust the squelch control to the position that requires the largest signal to unsquelch the receiver. Adjust the input signal level until the squelch just opens. Record this level in µV or dB (µV).

l) Reduce the input signal level until the squelch just closes. Record the signal level in µV or dB (µV).

27.1.3 *Method of measurement for receivers having pre-set squelch controls*

Perform the measurements according to Sub-clause 27.1.2, Steps *a), b), c), d), i)* and *j)*, and record the signal levels obtained in Steps *i)* and *j)*.

27.1.4 *Presentation of results*

Calculate the value of the squelch opening and closing levels in dB (µV/m) using the following tabulation:

X	Y	Z	X−Y+Z
Reference radiation sensitivity in dB (µV/m)	Value recorded in Step *d)* in dB (µV)	Value recorded as given below in dB (µV)	Squelch opening and closing levels in dB (µV/m)
		Step *i)*: Step *j)*: Step *k)*: Step *l)*:	Minimum squelch opening Minimum squelch closing Maximum squelch opening Maximum squelch closing

Example:

X	Y	Z	X−Y+Z
Reference radiation sensitivity in dB (µV/m)	Value recorded in Step *d)* in dB (µV)	Value recorded as given below in dB (µV)	Squelch opening and closing levels in dB (µV/m)
9	28	Step *i)*: 17	Minimum squelch opening −2
9	28	Step *j)*: 14	Minimum squelch closing −5
9	28	Step *k)*: 22	Maximum squelch opening +3
9	28	Step *l)*: 20	Maximum squelch closing +1

27.2 *Squelch opening and closing delays*

27.2.1 *Definition*

The intervals between the time of occurrence of a specified increase or decrease of the level of a modulated radio-frequency input signal and the time at which the audio output level is 50% of its steady-state unsquelched value.

27.2.2 *Method of measurement*

a) Add the following to the equipment illustrated in Figure 7, page 84:

1) an oscilloscope having a calibrated horizontal sweep connected in parallel with the input to the distortion factor meter,

2) an electronically controlled, single-step attenuator, having a difference of at least 30 dB between its two states, connected between the input signal source and combining network.

Note. – The switching time of the attenuator should be short compared with the expected squelch opening and closing times.

b) Operate the receiver with no input signal. If equipped with an adjustable squelch control, adjust it to the position where the squelch just closes (see Sub-clause 27.1.2, Step *h)*).

c) Apply the standard input signal and operate the receiver at the reference output level. Note this on the oscilloscope.

d) With the 30 dB single-step attenuator at the maximum attenuation value, adjust the input-signal level to a value which is 6 dB below the value at which the squelch just closes.

e) Derive the synchronizing pulse for the calibrated horizontal sweep of the oscilloscope from the attenuator activating signal.

f) Change the attenuation of the step attenuator from maximum to minimum. Measure and record the interval between the time the attenuation is changed and the time the audio output level is increased to and remains above 50% of the value noted in Step *c)*. Record this interval as the squelch opening delay.

g) Change the attenuation of the step attenuator from minimum to maximum. Measure and record the interval between the time that the attenuation is changed and the time that the output level decreases by 50%. This interval is the squelch closing delay.

Note. – A variation of this method may be used whereby a dual-trace storage oscilloscope is made to show on one trace the radio-frequency signal and on the other trace the audio-frequency signal.

28. **Signal-to-residual output-level ratio**

This measurement is only applicable to the H3E mode.

28.1 *Definition*

The ratio, in decibels, of

the rated audio-output level

to

the residual audio-output level in the absence of modulation, both measured at a specified input signal level.

28.2 *Method of measurement*

a) Connect the equipment as illustrated in Figure 7, page 84.

b) Where possible, adjust the squelch control to the unsquelched position.

c) Apply a standard input signal to the input of the RFCD and adjust the level to be 60 dB greater than that which produces the standard signal-to-noise ratio (see Sub-clause 5.3).

d) Operate the receiver at the rated audio-output level.

e) Remove the modulation signal and record the reduction, in decibels, of the audio-frequency output level as the signal-to-residual output-level ratio.

28.3 *Presentation of results*

Record the signal-to-residual output-level ratio obtained in Step *e)*, and the rated audio-frequency output-level.

Note. – When required by the equipment specification, the measurement may be carried out for various values of the input level so that a graphical representation can be made of the ratio of signal-to-noise as a function of input-signal level.

29. Selectivity

29.1 *General*

Selectivity is the ability of the receiver to discriminate between wanted and unwanted input signals. It can be evaluated by measuring the adjacent-signal selectivity, the spurious response, crossmodulation and blocking or desensitization.

The methods of measurement described in this clause deal only with interference that degrades the wanted receiver output signal due to the simultaneous presence of an unwanted input signal. It is to be noted, however, that unwanted signals may also be objectionable when the wanted signal is not present.

Note. – It is important that the signal generators used in the following measurements be free of spurious emissions. If spurious emissions do exist, notch filters should be used to eliminate them.

29.2 *Adjacent-signal selectivity*

29.2.1 *Definition*

The ratio of

the level of an unwanted input signal that reduces the signal-to-noise ratio produced by a signal 3 dB in excess of the reference sensitivity (RFCD) to the standard signal-to-noise ratio

to

the reference sensitivity (RFCD).

Blocking is a particular case of adjacent-signal selectivity where the difference between the unwanted signal frequency and the standard input-signal frequency is a specified amount greater than 1% of the standard input-signal frequency.

29.2.2 *Method of measurement*

a) Connect the equipment as illustrated in Figure 7, page 84, and connect an additional generator (G3) to the matching and combining network (see Appendix A).

b) Operate the receiver and, in the absence of the unwanted signal, apply the standard input signal by means of the combining network and adjust its level to obtain the standard signal-to-noise ratio in accordance with Sub-clause 23.2. Record this level in μV or dB (μV).

Note. – If the measuring arrangement is exactly the same, the reference sensitivity (RFCD) value may be used for Step *b)* (see Clause 23).

c) Increase the level of the wanted input signal by 3 dB.

d) Apply an unwanted, unmodulated input signal from generator (G3) to terminal C of the matching and combining network.

e) Adjust the unwanted signal frequency by a specified amount above and below the wanted carrier frequency outside the passband of the receiver. At each frequency adjust the unwanted level so as to re-establish the standard signal-to-noise ratio. Record the level of the unwanted signals in μV or dB (μV).

f) Calculate the ratios, in decibels, of the unwanted signal levels measured in Step *e)* to the level recorded in Step *b)*. The smaller value is the adjacent-signal selectivity.

g) Steps *e)* and *f)* may be repeated for other values of frequency displacement.

Note. – The results may be displayed in a table.

29.3 *Adjacent-channel selectivity*

Where mobile radio services use discrete channel spacings, the value of adjacent-signal selectivity measured with a signal spacing equal to the discrete channel spacing, may be quoted as the value of the adjacent-channel selectivity, for a given frequency spacing of the channels.

29.4 *Crossmodulation*

Under consideration.

29.5 *Spurious-response immunity*

29.5.1 *Definition*

The ability of the receiver to prevent single unwanted signals from causing an unwanted response at the output of the receiver.

It is expressed as the ratio, in decibels, of:

a) the level of a single unwanted signal that reduces the signal-to-noise ratio, produced by a wanted signal 3 dB in excess of the reference sensitivity, to the standard signal-to-noise ratio

to

b) the reference sensitivity (RFCD).

29.5.2 *Method of measurement*

Note. – A very wide search frequency range is usually specified for this measurement. It is important that the field strength be constant when the frequency is varied or that the relationship of field strength versus frequency be known over the search frequency range, for the RFCD used in this measurement.

a) Orient the equipment so that a face, specified by the manufacturer, is normal to the input axis of the RFCD. This orientation is the reference for the measurement of the azimuth.

This measurement requires that the equipment under test be placed in the same RFCD and in the same position as used for the measurement of reference sensitivity (RFCD) (see Appendix J).

If the receiver has an integral speaker, see Appendix F.

b) Connect the equipment as illustrated in Figure 7, and connect a second radio-frequency signal generator (unwanted signal source) (G3) to terminal C of the matching and combining network (3) (see Appendix A).

c) Apply to the RFCD an input signal level that is 60 dB greater than the sensitivity (RFCD), and adjust the audio frequency gain to obtain the reference output level.

d) In the absence of the unwanted signal, apply the standard input signal (see Sub-clause 5.3) to terminal A of the combining network, and adjust its level to obtain the standard signal-to-noise ratio in accordance with Sub-clause 23.2. Record this level in µV.

e) Increase the level of the wanted input signal by 3 dB.

f) Adjust the input signal to a high-level unwanted, unmodulated input signal for example, 90 dB greater than the reference sensitivity (RFCD).

g) Vary the unwanted input signal frequency over the specified frequency range to search for degradation of the signal-to-noise ratio. When a response is found, carefully adjust the frequency of the unwanted signal to maximize the degradation.

h) At the frequency of each spurious response, change the level of the unwanted input signal until the standard signal-to-noise ratio is obtained at the receiver output.

Record the frequency of the unwanted input signal, and record its level at the input of the RFCD in μV.

i) Rotate the equipment under test in steps of 45°, and repeat Steps *c)* to *h)*. Continue until eight azimuth positions have been measured.

29.5.3 *Presentation of results*

a) Correct and record the levels recorded in Sub-clause 29.5.2, Step *d)*, using the departure values measured in Appendix J, Sub-clause J3.2.

b) Correct and record the levels recorded in Sub-clause 29.5.2, Step *h)*, using the departure values measured in Appendix J, Sub-clause J3.2.

c) Calculate the average of the eight (8) levels (in μV) recorded in Step *a)*.

d) Calculate, for each spurious response, the average of the eight (8) levels (in μV) recorded in Step *b)*.

e) Calculate, for each spurious response, the ratio, in decibels, of the average calculated in Step *d)* to the average calculated in Step *c)*.

f) Tabulate the ratios obtained in Step *e)* together with their respective spurious-response frequencies. Record the nominal operating frequency.

29.6 *Intermodulation immunity*

29.6.1 *Definition*

The ability of the receiver to prevent two unwanted input signals, with a specific frequency relationship to the wanted signal frequency, from causing an unwanted response at the output of the receiver due to intermodulation.

It is expressed as the ratio, in decibels, of:

a) the level of two equal-level unwanted signals that reduce the signal-to-noise ratio produced by a wanted signal 3 dB in excess of the reference sensitivity (RFCD) to the standard signal-to-noise ratio

to

b) the reference sensitivity (RFCD).

Note. – Refer to Appendix D for frequency relationships likely to result in an unwanted response due to intermodulation.

29.6.2 *Method of measurement*

a) Connect the equipment as illustrated in Figure 7, page 84, and connect two additional signal generators (unwanted signal sources) to an appropriate matching and combining network (see Appendix A for examples of combining networks).

b) In the absence of unwanted signals, apply the standard input signal (see Sub-clause 5.3) to the matching and combining network. Adjust its level to obtain the standard signal-to-noise ratio. Record this level in μV or dB (μV).

Note. – If the measuring arrangement is exactly the same, the reference sensitivity (RFCD) value may be used for Step *b)* (see Clause 23).

c) Increase the level of the wanted signal by 3 dB.

d) Apply an unwanted, unmodulated input signal and adjust its value to a specified frequency f_n.

e) Apply an unwanted, unmodulated input signal and adjust its value to a specified value f_r.

f) Incrementally increase the levels of the two unwanted signals until the wanted signal-to-noise ratio is degraded.

g) Carefully adjust the frequency of one of the unwanted signals to maximize the degradation.

h) Adjust the levels of the unwanted signals to be equal at the input to the RFCD and to produce the standard signal-to-noise ratio at the receiver output. Record this level in μV or dB (μV).

i) Calculate the ratio, in decibels, of the level recorded in Step *h)* to the level recorded in Step *b)*. This ratio is the intermodulation immunity for the unwanted frequencies concerned.

Note. – Measuring errors may result from intermodulation between generators, generator noise, or receiver desensitization. See Appendix B for precautions regarding the signal generators.

30. **Automatic gain control (A. G. C.) characteristics**

30.1. *Definition*

The change in output levels as a function of the level of the input signal.

30.2 *Method of measurement*

a) Connect the equipment as illustrated in Figure 7 and connect an additional generator (G3) to the matching and combining network.

b) Apply a standard input signal to the input of the RFCD (see Sub-clause 5.3), and adjust the level to produce the standard signal-to-noise ratio. Record this level in μV or dB (μV).

c) Increase the input signal level by 100 dB.

d) Reduce the level of the necessary sideband by 10 dB. Note this level.

e) For reception mode J3E apply a signal from the additional generator (G3) at a level of 10 dB above that noted in Step *d)* to produce an additional 1 600 Hz signal at the receiver output.

f) Adjust the receiver to obtain the reference output level.

g) Progressively reduce the composite signal level and record the 1 000 Hz audio-frequency output signal level for each value of composite signal level. Continue until the level recorded in Step *b)* is reached.

h) The measurement may be continued at lower input signal levels to determine the performance at levels below the level which will produce the standard signal-to-noise ratio.

i) The measurement may also be extended to levels above that used in Step *c)* to identify the upper limit of the A. G. C. characteristics.

30.3 *Presentation of results*

Plot the relative level of the output (1 000 Hz), in decibels, on the linear ordinate of a graph and the input signal level, in decibels, relative to the value which produces the standard signal-to-noise ratio as recorded in Step *b)* on the linear abscissa. Record the audio output level recorded in Step *f)*. Alternatively a table of values may be presented.

30.4 *Dynamic automatic gain control characteristic*

30.4.1 *General*

The dynamic automatic gain control characteristic is the transient effect upon the level of the output signal caused by a sudden change in input signal level. It is defined in terms of its attack and recovery times.

30.4.2 *Definition – A. G. C. attack time*

The elapsed time from the instant at which the input signal level is suddenly increased by a specified amount until the instant at which the level of the output signal reaches and remains within ±2 dB of the subsequent steady-state value.

30.4.3 *Method of measurement*

a) Connect the equipment as illustrated in Figure 7, page 84, and connect an oscilloscope in parallel with the distortion factor meter.

b) Connect an electrically controlled attenuator capable of providing a specified change in input signal level (for example, 20 dB) between the radio-frequency signal source and the matching and combining network.

c) Set the attenuator to its maximum attenuation.

d) Apply a standard input signal to the input of the RFCD (see Sub-clause 5.3) and adjust the level to produce the standard signal-to-noise ratio.

e) Operate the receiver to produce an audio output level of 20 dB below the rated output level.

f) Trigger the calibrated horizontal sweep of the oscilloscope by the attenuator control signal.

g) Actuate the attenuator to decrease its attenuation, by 20 dB, for example.

h) Measure the time between the instant of actuating the attenuator and the instant after which the 1000 Hz output signal reaches and remains within ±2 dB of the subsequent steady-state level (points A and B in Figure 5, page 47). Record this as the A. G. C. attack time.

30.4.4 *Definition – A. G. C. recovery time*

The elapsed time from the instant when the input signal level is suddenly decreased by a specified amount until the instant at which the output signal reaches and remains within ±2 dB of the subsequent steady-state value.

30.4.5 *Method of measurement*

a) Carry out Steps *a)* to *g)* of Sub-clause 30.4.3 except arrange to decrease the input level by 20 dB at the moment of change. The radio-frequency input-signal level initially applied should be approximately 20 dB greater than the reference sensitivity.

b) Actuate the attenuator to increase its attenuation.

c) Measure the time between the instant of actuating the attenuator and the instant after which the output signal reaches and remains within ±2 dB of the subsequent steady-state level (points C and D in Figure 5). Record this as the A. G. C. recovery time.

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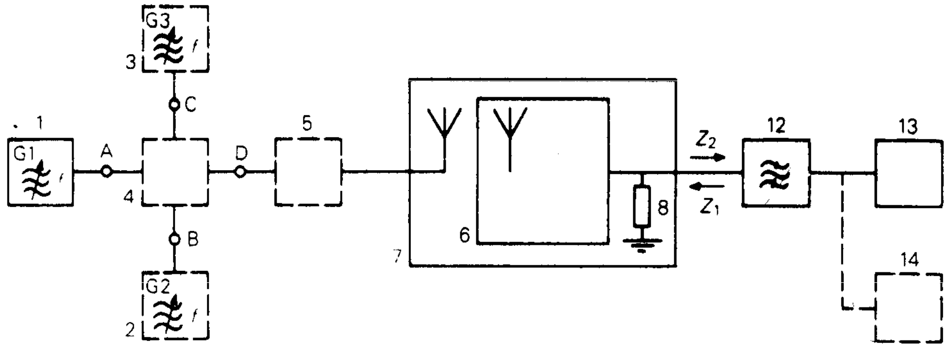


FIG. 7*a*. – Arrangement for receiver having audio frequency output terminals but no integral output transducer.

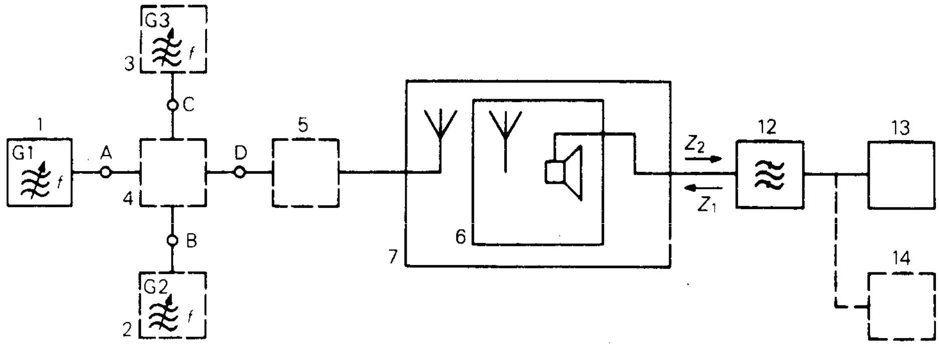


FIG. 7*b*. – Arrangement for receiver having an integral output transducer to which connections can be made.

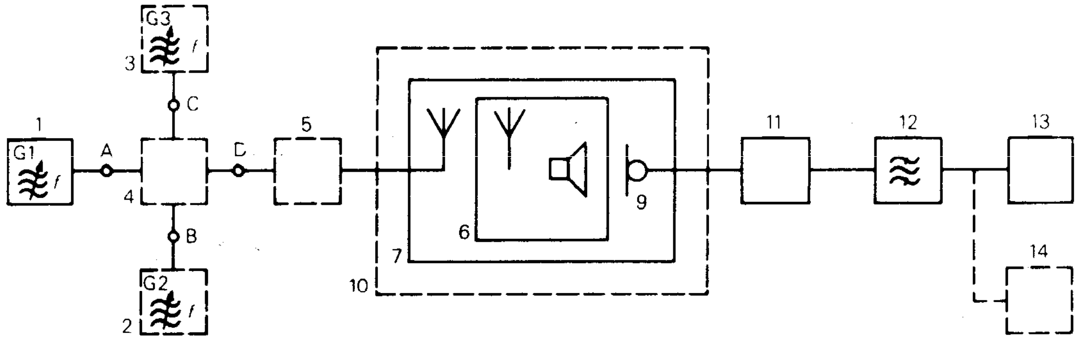


FIG. 7*c*. – Arrangement for receiver having an integral output transducer where direct connection is not possible.

1 radio-frequency signal generator
2 radio-frequency signal generator, if required

3 radio-frequency signal generator, if required

4 matching and combining network, if required
5 artificial antenna, if required
6 receiver under test
7 radio-frequency coupling device (RFCD)

8 audio-frequency load (refer to Section One)
9 microphone (part of sound level meter)
10 acoustic isolation enclosure
11 sound level meter
12 band-limiting filter (refer to Section One)
13 distortion factor/audio level meter
14 selective measuring device

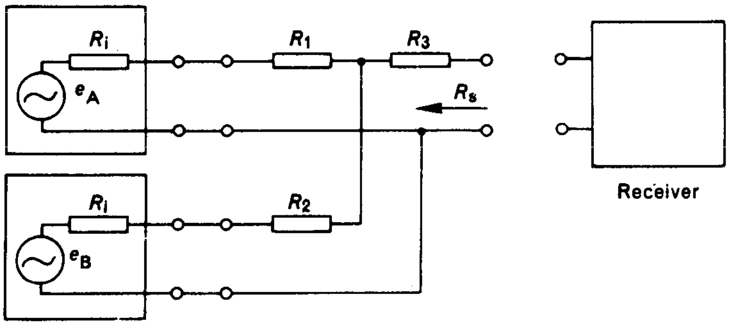
FIG. 7. – Dispositifs de mesure des caractéristiques de récepteurs à antenne intégrée.
Arrangements for measuring the characteristics of receivers having integral antennas.

APPENDIX A

EXAMPLES OF COMBINING NETWORKS

A1. Examples of simple combining networks

Figures A1 and A2 illustrate examples of resistance networks suitable for combining the output signals of two or three signal generators.

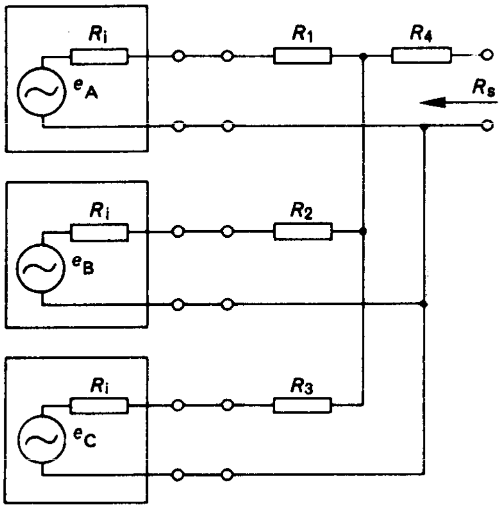


Note. – The source impedance R_s of the network is equal to R_i if:

$$R_1 = R_2 = R_3 = \frac{R_i}{3}$$

In this case, the network attenuation is about 6 dB.

FIG. A1. – Network for combining two signals.



Note. – The source impedance R_s of the network is equal to R_i if:

$$R_1 = R_2 = R_3 = R_4 = \frac{R_i}{2}$$

In this case, the network attenuation is about 10 dB.

FIG. A2. – Network for combining three signals.

A2. Examples of networks providing higher isolation between signal generators

Resistance networks, as shown in Figures A1 and A2, may not provide sufficient isolation between signal generators to avoid intermodulation products appearing in their output. The high isolation networks described in Notes 1 and 2 reduce this effect.

Notes 1. – See IEC Publication 315-2 (Clause 12 and Figures 1, 2 and 3).

2. – An example of a combining network using a hybrid ring is shown in Figure A3. The operation of this device is as follows:

The coaxial cable of the hybrid ring is cut to lengths of multiples of a quarter wavelength of the median frequency. The power from signal generator G_A will then be divided equally between the termination point A (provided the network is loaded at that point by a resistance R_i) and the resistor R_1, the value of which is equal to R_i. The signals from signal generator G_A at the output terminals of signal generator G_B will cancel each other since the two paths differ by half a wavelength.

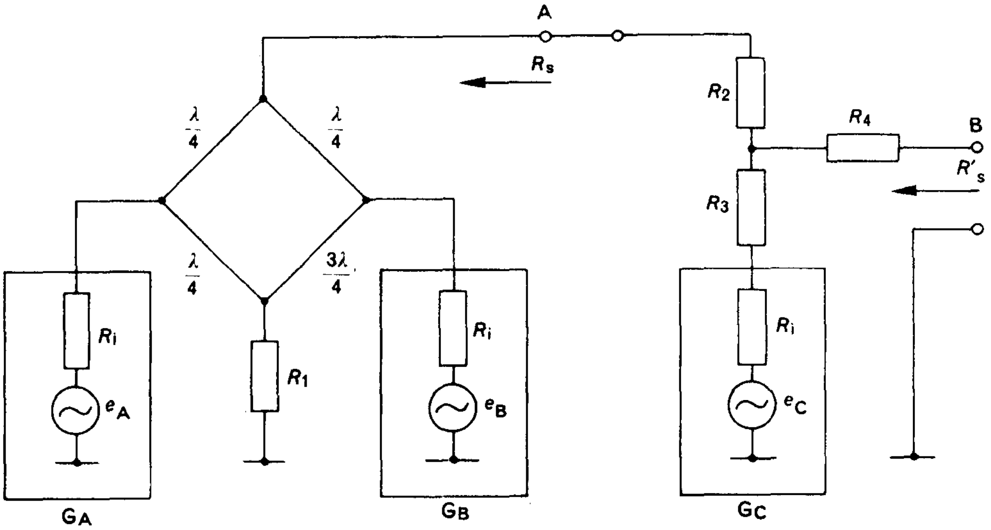
The power from signal generator G_B is similarly divided and its signal at the output of the signal generator G_A cancelled.

Because the coaxial cable of the hybrid ring has a relatively low quality factor (Q), the cancellation will be effective over a wide range of frequency difference between the frequencies of the generators G_A and G_B.

The source impedance R_s, of the left-hand part of the network at point A is equal to R_i (for example 50 Ω) if the characteristic impedance of the cable is $R_i\sqrt{2}$ (for example 71 Ω).

If, for certain measurements, a wanted signal in combination with two unwanted signals is needed, the third generator, G_C, supplying the wanted signal shall be connected to point A by means of the combining network shown in the right-hand part of Figure A3.

The source impedance, R'_s, of the complete network at point B is equal to R_i (for example 50 Ω) if $R_2 = R_3 = R_4 = \frac{R_i}{3}$

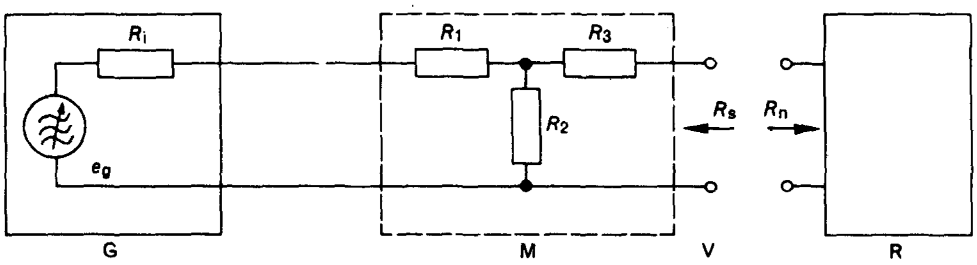


G_A and G_B = signal generators.
G_C = additional signal generator, when required.

FIG. A3. – Example of combining network using a hybrid ring.

A3. Example of an input-signal source-matching network

Other examples of such networks are given in Clause 45 of IEC Publication 315-1.



G = radio-frequency signal generator
M = matching network
R = receiver

$$R_2 = \frac{2\sqrt{N R_i R_n}}{N-1}$$

$$R_1 = R_i \left(\frac{N+1}{N-1}\right) - R_2$$

$$R_3 = R_n \left(\frac{N+1}{N-1}\right) - R_2$$

where N is the required power loss ratio.

FIG. A4. – Example of a matching network.

APPENDIX B

SUPPLEMENTARY RECOMMENDED METHODS FOR TESTING MEASURING ARRANGEMENTS

B1. **Method for testing intermodulation characteristics of the signal generators**

The intermodulation in the signal generators may be tested by the following procedure:

Insert a variable attenuator between the combining network and the receiver under test. Increase the attenuation in steps of 1 dB and increase the output voltages of the generators by the same amounts, thus maintaining the original level at the input to the receiver.

Since the intermodulation products in the output should remain constant, any increase is caused by intermodulation in the signal generators.

B2. **Method of testing signal generator noise**

The measurement of certain characteristics, for example adjacent channel selectivity, can be erroneous when a signal generator having a high spectral noise constant is used.

At frequencies below 200 MHz, a crystal filter having at least 20 dB rejection at the adjacent channel can be connected at the output of the generator under test as a means of assessing whether a result is influenced by signal generator noise.

APPENDIX C

GENERAL INFORMATION ON IMPULSIVE NOISE AND RANDOM-IMPULSE GENERATOR

C1. General

One of the major sources of impulsive interference in receivers and decoders used in the mobile services is the ignition system of internal-combustion engines. The noise radiated by ignition systems is characterized by a great number of pulses of various amplitudes and spacings. The number of pulses per time unit exceeding a given value and measured in a given frequency band forms part of the spectrum signature of a noise environment.

The complete noise-amplitude distribution cannot be generated easily for the purpose of evaluating receiver performance. A random-impulse generator can, however, be used to simulate the noise produced by city traffic. This has been found to be an effective method of measuring degradation of receiver performance due to impulsive noise.

C2. Random-impulse generator characteristics

A block diagram of an example of a random-impulse generator is shown in Figure C1, page 102.

The random-impulse generators used in the measurements in this standard are of the pulsed carrier type.

C2.1 *Spectrum bandwidth*

The output spectrum should be uniform within 0.5 dB, over the r. f. bandwidth of the receiver being measured.

The spectral amplitude for an individual carrier pulse shall be uniform, within 0.5 dB, up to a radio input-signal frequency f (in MHz), of $\pm 186/\tau$, where τ is the duration of the equivalent rectangular pulse in nanoseconds. The pulse duration of the generator is an important factor to consider when determining the offset of the carrier frequency from the nominal frequency of the receiver.

C2.2 *Output*

The output of a random-impulse generator is in spectrum amplitude. The spectrum amplitude produced by impulsive noise within a given frequency band is the vector sum of the voltage within that frequency band, divided by the bandwidth; it is expressed, for example, in µV/MHz or dB (µV)/MHz.

Note. – When the output is observed on a wide band oscilloscope, it will be a series of short pulses of the carrier. When observed on a narrow bandwidth spectrum analyser, it will be a $(\sin x)/x$ type frequency distribution.

The random-impulse generator should be calibrated in dB (µV)/MHz with an accuracy of ±1 dB, and have a source impedance (R_i) equal to the impedance of the receiver (for example, 50 Ω), including the matching and combining network. The output is a voltage measured across a test load of 50 Ω.

C2.3 *Average impulse rate*

The random-impulse generator should have an average impulse rate of 100 impulses per second (i/s).

C2.4 *Random distribution of impulses*

The time interval between impulses is random. The distribution of the impulses is given by a Poisson distribution.

One way to generate a satisfactory random distribution is to apply to an "and" circuit the output of three pseudo-random binary sequence pattern generators having lengths of 20, 21 and 22 bits, clocked at 800 bits per second. The output of the "and" circuit is used to trigger the impulse. The average impulse rate should be 100 i/s and the probability density should closely approximate that of a Poisson distribution.

C2.5 *Random distribution of the spectrum amplitude and the amplitude correlation*

The amplitude of each carrier pulse is random. The probability density is given by a log-normal distribution that has a standard deviation of 6 dB. The amplitude correlation between carrier pulse is defined as that produced by band limited noise of 10 Hz bandwidth.

One way to generate a satisfactory random-amplitude distribution is to pass flat noise through a low-pass filter with a 10 Hz cut-off frequency. The probability density of this noise should have a normal distribution. It is used to modulate the amplitude of the carrier pulses using a modulator that has an exponential characteristic. The standard deviation of the log-normal amplitude distribution can be varied by adjusting the magnitude of the noise applied to the modulator.

C3. **Calibration of the spectrum amplitude**

a) Connect the output of the random-impulse generator to a test load and connect an oscilloscope to measure the voltage across the test load.

b) Set the frequency of the radio frequency signal generator to the nominal frequency of the receiver to be measured.

c) Adjust the controls of the random-impulse generator to the following:

- attenuator to its minimum value,
- pulse width to 0.2 μs,
- standard deviation to 0 dB,
- pulse rate to a constant (if possible).

Note. – Most oscilloscopes will be triggered by an impulse even if the impulses occur at random.

Record the attenuation value.

d) With the oscilloscope adjusted to display one pulsed carrier impulse, measure the peak voltage of the impulse. Record the peak voltage in microvolts.

e) Measure the time between the two points where the envelope of the impulse crosses the level that is 50% of the value recorded in Step *d)*. Record the time in microseconds.

f) Calculate the spectrum amplitude of the impulsive noise as follows:

$$S = \frac{\tau V}{\sqrt{2}} \quad \left(\frac{\mu V}{\mathrm{MHz}}\right)$$

where:

S is the spectrum amplitude in μV/MHz
V is the voltage recorded in Step *d)* in μV
τ is the time period recorded in Step *e)* in microseconds

This formula is valid only for that part of the frequency band in which the spectrum amplitude can be considered constant.

Note. – An impulse of 0.2 μs duration will have a frequency distribution that is constant over a bandwidth of ±0.93 MHz.

Record the spectrum amplitude as the minimum attenuation median spectrum amplitude.

C.4 **Performance verification of the random-impulse generator**

This verification applies to the pulse distribution and the amplitude distribution.

C4.1 *Verification that the pulse distribution is Poisson*

C4.1.1 *Method of measurement*

a) Connect the equipment as illustrated in Figure C2, page 102.

b) Adjust the controls of the random-impulse generator as follows:

- attenuator to its minimum value,
- pulse width to 0.2 μs,
- standard deviation to 0 dB,
- pulse rate to random.

c) Adjust the counter to measure the number of impulses that occur within a 0.1 s period. Measure 1000 periods, at random, and record in Table CI the number of periods where 5, 6, 7 . . . or 15 pulses occurred.

C4.1.2 *Presentation of results*

If the number of periods recorded in Table CI is within the specified limits, record that the random-impulse generator complies with this standard for the pulse distribution.

TABLE CI

Number of pulses per period	Lower limit	Measured (number of periods)	Upper limit
5	30		46
6	50		74
7	72		109
8	90		136
9	100		151
10	100		151
11	90		137
12	75		114
13	58		88
14	41		63
15	27		42

C4.2 *Verification that the amplitude distribution is log-normal*

C4.2.1 *Method of measurement*

a) Adjust the random-impulse generator to a standard deviation of 0 dB.

b) Apply the r. f. output signal to an envelope detector with a logarithmic characteristic (for example, a spectrum analyzer), set to zero scan mode and set to a decibel scale. Record *V*, the pulse amplitude, in decibels.

c) Adjust the random impulse generator to a standard deviation of 6 dB.

d) Measure and record the amplitude, in decibels, of 1000 independent samples of the pulse amplitude. Take the samples at a rate of about one per second.

C4.2.2 *Presentation of results*

a) For each sample *i*, calculate *Z* where:

$$Z_i = X_i - V \quad \text{in decibels}$$

where:

V is the amplitude recorded in Sub-clause C4.2.1, Step *b)*

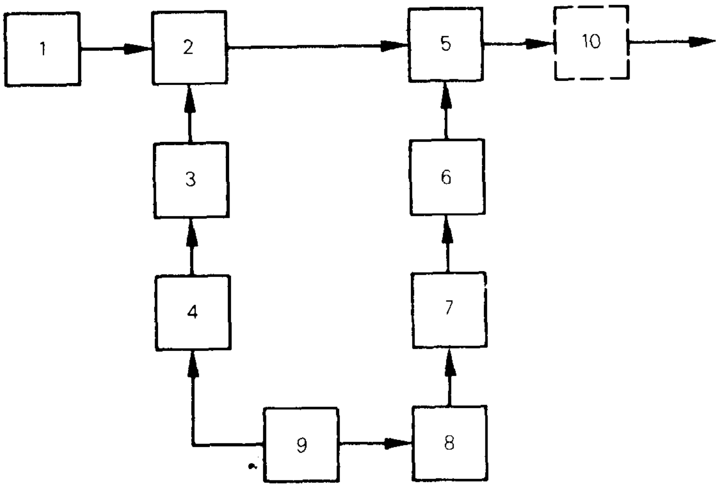
X_i is the amplitude recorded in Sub-clause C4.2.1, Step *d)*

TABLE CII

Z dB (less than)	Lower limit	Measured (number of samples)	Upper limit
-15	1		13
-14	2		19
-13	6		27
-12	10		38
-11	18		52
-10	28		71
-9	42		95
-8	62		125
-7	86		162
-6	117		205
-5	155		254
-4	200		309
-3	251		370
-2	307		434
-1	434		500
0	500		566
1	566		631
2	630		693
3	691		749
4	746		800
5	795		845
6	838		883
7	875		914
8	905		938
9	929		953
10	948		972
11	962		982
12	973		990
13	973		994
14	981		998
15	987		999

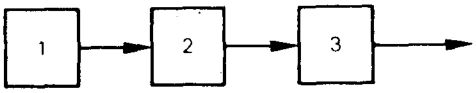
b) Record in Table CII the number of samples that have a value of *Z* that is less than the values indicated.

c) If the number of samples recorded in Table CII is within the specified limits, record that the random-impulse generator complies with this standard for log-normal amplitude distribution.



1 = Radio-frequency signal generator
2 = Product modulator
3 = Impulse generator
4 = Poisson distribution generator
5 = Exponential modulator
6 = Gain adjustment
7 = Low pass filter
8 = Noise generator
9 = Clock
10 = Internal attenuator

FIG. C1. – Example of a random impulse generator.



1 = Random-impulse generator
2 = Envelope detector
3 = Frequency counter

FIG. C2. – Measuring arrangement for measurement of impulse distribution.

REFERENCES

[1] "Impulsive Noise Simulator for Land Mobile Radio Communication." K. Kobayashi, T. Hattori, *Trans. IECE* 1979/10, Vol. 62-B, No. 10, pp. 925–931.
Transactions of the IECE of Japan, Vol. E62, No. 10. Abstracts.

[2] "Impulsive Noise Simulator Type INS 81A." Micro Control Systems Limited, 102 Lower Guildford Road, Knaphill, Woking, Surrey, GV 21, 2EP England.

[3] "City Noise Simulator NJZ-317." Japan Radio Co. Ltd., Mori Building 5th 17-1, Toranomon 1 chome, Minato-ku, Tokyo 105, Japan.

[4] "IEEE Standard for the Measurement of Impulse Strength and Impulse Bandwidth." *IEEE Std* 376-1975. Institute of Electrical and Electronics Engineers, Inc., 345 East 47 Street, New York, N.Y. 10017, USA.

APPENDIX D

INTERMODULATION RESPONSE

D1. **Intermodulation response**

Intermodulation responses corresponding to the intermediate frequency are not significant in this class of equipment.

Unwanted-signal frequencies which may produce an intermodulation response are related to the wanted-signal frequency as follows:

D1.1 *Second-order relationship*

$$f_w = f_r \pm f_n$$

Note. – Commonly used frequency relationships include:

$f_n = f_w + \Delta f$ $\quad$ $f_n = f_w - \Delta f$

or

$f_r = 2f_w + \Delta f$ $\quad$ $f_r = 2f_w - \Delta f$

D1.2 *Third-order relationship*

$$f_w = 2f_n \pm f_r$$

Note. – Commonly used frequency relationships include:

$f_n = f_w + \Delta f$ $\quad$ $f_n = f_w - \Delta f$

or

$f_r = f_w + 2\Delta f$ $\quad$ $f_r = f_w - 2\Delta f$

D1.3 *Fifth-order relationship*

$$f_w = 3f_n \pm 2f_r$$

Note. – Commonly used signal frequency relationships include:

$f_n = f_w + \Delta f$ $\quad$ $f_n = f_w - \Delta f$

or

$f_r = f_w + 1.5\Delta f$ $\quad$ $f_r = f_w - 1.5\Delta f$

where:

f_w is the frequency of the wanted signal
f_n is the frequency of the nearer unwanted signal
f_r is the frequency of the more remote unwanted signal
Δf is the frequency difference between the wanted signal and the nearer unwanted signal

Other intermodulation orders exist. However, selection of a reasonable number of frequencies f_n and f_r is generally sufficient to describe the performance of the equipment considered in this standard with respect to intermodulation.

APPENDIX E

EXAMPLE OF A MAINS POWER LINE IMPEDANCE STABILIZATION NETWORK

E1. **Introduction**

A mains power line impedance stabilization network is required to provide defined impedances at high frequencies between the mains terminals of the receiver and between each of these terminals and earth. The network also provides a suitable filter to isolate the receiver circuit from unwanted radio-frequency voltages that may be present on the supply mains.

The impedance of this filter section at the measuring frequency shall be sufficiently high for the combination of filter and associated network as represented in Figure E1, page 110, to give an impedance having a modulus of 150 ± 20 Ω and a phase angle not exceeding 20°, both between the terminals of the receiver and between these two terminals connected together and earth.

The symmetrical voltage is the voltage appearing between terminals A and B (see Figure E1).

The asymmetrical voltage is the voltage appearing between terminal C and the earth (see Figure E1).

These voltages may be represented in a theoretical vector diagram as indicated in Figure E2, page 110.

E2. **Method of measuring interference voltage**

For practical measurements, a mains power line impedance stabilization network (also known as artificial mains network), similar to the example given in Figure E3, page 111, may be used. This network is suitable for measuring both symmetrical (position 1 of switch S) and asymmetrical (position 2 of switch S) components, with an unbalanced selective voltmeter.

TABLE EI

Resistance, attenuation and impedance values of the artificial mains network of Figure E3 (Note 1) for three different input impedances Z, of the measuring equipment.			
	$Z = 50\,\Omega$	$Z = 60\,\Omega$	$Z = 75\,\Omega$
Resistances (Note 2)			
$R_1 = R_2$	118.7 (120) Ω	112.2 (110) Ω	107.1 (110) Ω
$R_3 = R_5$	152.9 (150) Ω	169.7 (160) Ω	187.5 (180) Ω
R_4	390.7 (390) Ω	483.9 (470) Ω	621.4 (620) Ω
$R_6 = R_7$	275.7 (270) Ω	230.3 (220) Ω	187.5 (180) Ω
$R_8 = R_9$	22.8 (22) Ω	27.6 (27) Ω	34.5 (36) Ω
$R_{10} = R_{11}$	107.8 (110) Ω	129.1 (130) Ω	161.3 (150) Ω
R_{12}	50 Ω	60 Ω	75 Ω
Attenuation (Note 3)			
Symmetrical A_{sym}	20 (20) dB	20 (19.7) dB	20 (19.8) dB
Asymmetrical A_{asym}	20 (19.9) dB	20 (19.8) dB	20 (20) dB
Artificial mains network impedance (Note 3)			
Symmetrical Z_{sym}	150 (150) Ω	150 (145.7) Ω	150 (151.2) Ω
Asymmetrical Z_{asym}	150 (148) Ω	150 (143.4) Ω	150 (145.2) Ω

Notes 1. – The ratio of turns of the balanced to unbalanced transformer in Figure E3, page 111, is assumed to be:

$\sqrt{\frac{2.5}{1}}$ with centre tap.

2. – Resistance values shown in brackets are the nearest preferred values (tolerance ± 5%).

3. – Values shown in brackets are calculated, using the preferred resistance values nearest to the theoretical values.

Allowance should be made for the attenuation introduced by this network. For all pertinent values, refer to Figure E3 and Table EI in this appendix.

An additional filter section may be required to prevent unwanted radio-frequency signals, carried by the mains power line network, from significantly influencing the measurements.

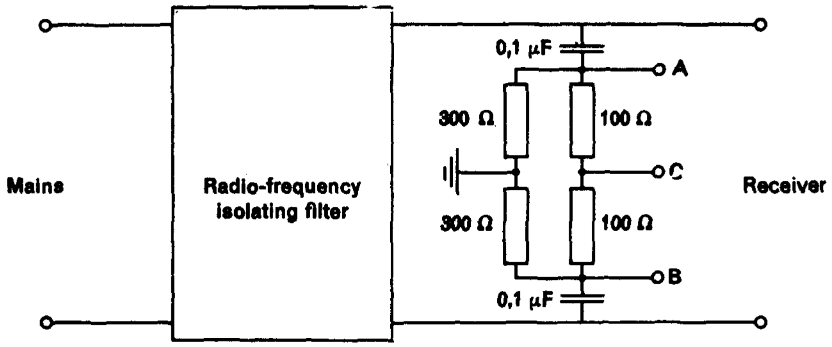


FIG. E1. – Mains power line impedance stabilization network (also known as artificial mains network).

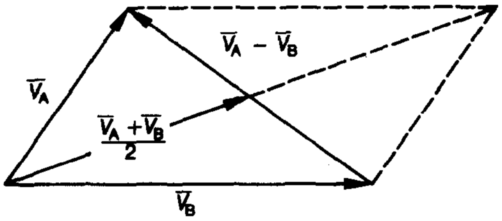
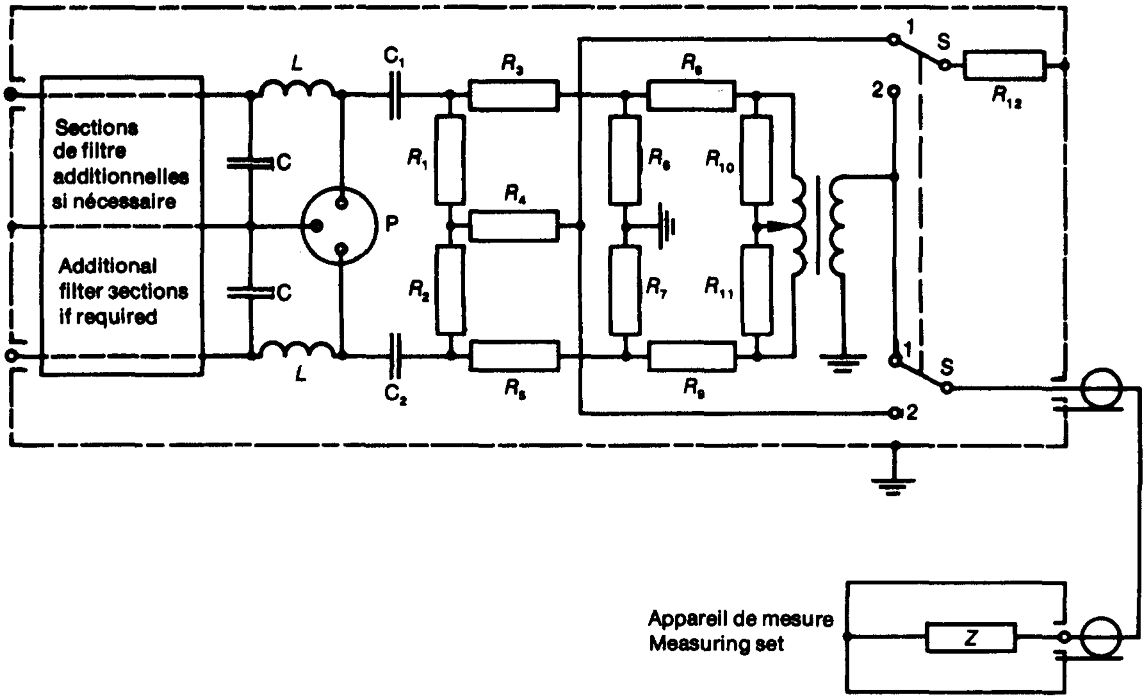

$\overline{V}_A$
$\overline{V}_A - \overline{V}_B$
$\frac{\overline{V}_A + \overline{V}_B}{2}$
$\overline{V}_B$

FIG. E2. – Vector diagram of interference voltages.



P = connections for receiver
1 = symmetrical component
2 = asymmetrical component

FIG. E3. – Example of a mains power line impedance stabilization network.

APPENDIX F

GUIDELINES FOR MEASURING, ON A RADIATION TEST SITE OR IN A RADIO-FREQUENCY COUPLING DEVICE (RFCD), THE AUDIO-FREQUENCY OUTPUT OF A RECEIVER HAVING AN INTEGRAL TRANSDUCER

F1. **Direct electrical connection measuring arrangement**

F1.1 *General*

When a receiver is being measured on a radiation test site or in a radio-frequency coupling device (RFCD), the audio output voltage should be conducted from the receiver to the remote indicator by a means that will not perturb the field near the receiver. This should be done by making direct electrical connection to the audio output terminals if they are available, or by making direct electrical connection to the speaker terminals.

F1.2 *Field perturbation from the measuring arrangement*

When objects having high electrical conductivity, such as copper wire, are present on a radiation test site or in an RFCD, the field will be perturbed. This perturbation can be minimized by fabricating the wires that are used to make the electrical connection between the remote indicator and the receiver from material which has high resistivity. The re-radiated fields from these connecting wires will be too weak to noticeably affect the radiation measurement results.

The wires should be long enough to ensure that the remote indicator can be located either beyond the edge of the radiation test site or below the ground surface. If an RFCD is used, the wires should be long enough so that presence of the remote indicator will not affect the measurement results.

F1.3 *Wire characteristics*

A flexible material having a resistivity of at least 0.28 Ωm (280000 Ω mm^2/m) should be used for the wires. A suitable wire can be made of carbon-impregnated polytetrafluoroethylene (PTFE).

F1.4 *Measurement arrangement considerations*

Even large diameter wire fabricated from this material will have a very high resistance. For example, 30 m of 3-mm-diameter wire will have a resistance of 1 MΩ. This does not present a problem for test equipment having a high input impedance (for example, greater than 1 MΩ), because SINAD is a ratio.

Because of the high input impedance of the test equipment and the high resistance of the wires, the capacitance between the wires should be minimal to avoid the effect of audio-frequency sensitivity of the measuring arrangement. The wires should be spaced over 100 mm apart over most of their length.

Carbon-impregnated PTFE wire will generate considerable noise when it is moved. Care should be taken, therefore, to ensure that there is no movement of the wire while the SINAD is being measured.

F1.5 *Precautions to be taken when using direct connections*

When the receiver has audio-frequency output terminals, a specified test load shall be connected across them. The test load should be as small as possible and its leads should be as short as possible. When connections are made to the speaker, the conducting material used to make the connection should have the smallest possible mass.

F2. Acoustic measuring arrangement to obtain the signal-to-noise ratio

F2.1 *General*

When a direct electrical connection to either the audio output terminals or the speaker terminals cannot be made, the signal-to-noise ratio may be measured by using an acoustic measuring arrangement.

It is not intended that measurements of audio-frequency response, harmonic distortion or audio intermodulation distortion be made by using the acoustic measuring arrangement.

In such an arrangement, the measured signal-to-noise ratio is a function of the response characteristics of the audio frequency amplifier, of the internal loudspeaker and of the acoustic coupling device. In this standard, radiofrequency parameter measurements that are made by using the acoustic coupling device should give the same results as though direct electrical connections were made across the speaker terminals. This is accomplished by using the acoustic SINAD instead of the standard SINAD in the methods of measurements.

In this standard the standard signal-to-noise ratio is 12 dB SINAD.

Acoustic SINAD is the signal-to-noise ratio of an acoustic signal which is produced by an acoustic transducer (speaker) when the SINAD measured by direct electrical connection is 12 dB. The acoustic SINAD may be several dB greater or less than 12 dB.

The manufacturer should open the receiver to make a direct electrical connection across the speaker (or output of the audio amplifier), and determine in the laboratory the acoustic SINAD which is equivalent to the 12 dB SINAD measured with direct connection to the transducer by using an acoustic coupling device, a microphone and a correcting network identical to those used on the test site (Figure F1, page 120). For the purpose of this standard, the acoustic coupling device shall be understood to mean the combination of the plastic funnel covering the loudspeaker, the 2 m acoustic tube and the fixture for positioning and supporting the equipment under test.

After the acoustic SINAD has been determined, all measurements made on the receiver in an RFCD or on a radiation test site will use the acoustic SINAD value whenever the standard signal-to-noise ratio is required.

Measurements of the output signal-to-noise ratio of a receiver shall be made by means of acoustic coupling to a microphone. On a radiation test site, all conducting materials used in the test equipment shall be placed below the surface, and the acoustic energy is conveyed from the receiver to the microphone by means of a non-conducting acoustic pipe.

When an RFCD is used, the same measuring arrangement may be used without placing the microphone below the ground surface.

The manufacturer shall establish the acoustic signal-to-noise ratio for the receiver and the test arrangement. The acoustic signal-to-noise ratio shall be used in all measurements that require measuring at the standard signal-to-noise ratio (12 dB SINAD).

The manufacturer shall supply or specify the acoustic coupling device and frequency correcting network.

If it is intended that the receiver be worn on a person, the acoustic coupling device shall be constructed to secure the receiver to the surface of the simulated man at the position specified.

F2.2 *Acoustic coupling device*

The acoustic pipe shall be long enough (for example, 2 m) to reach from the equipment under test to the underground surface where the microphone is located (see Figure F2). The acoustic pipe shall have an inner diameter of about 6 mm and a wall thickness of about 1.5 mm. A plastic funnel having a diameter appropriate to the size of the loudspeaker in the equipment under test, with soft foam rubber glued to its edge, shall be fitted to one end of the acoustic pipe, and the microphone shall be fitted to the other end. The acoustic pipe should be sufficiently flexible to allow the platform to rotate. The microphone shall have a response characteristic that is flat within 1.0 dB over a frequency range of 50 Hz to 20000 Hz, a linear dynamic range of at least 50 dB, and a sensitivity sufficient to measure a signal-to-noise ratio of 40 dB. Its size should be sufficiently small (for example, 7.5 mm) to couple to the acoustic pipe (see Figure F2).

F2.3 *Frequency correcting network*

The influence of the relatively large funnel volume feeding the small diameter pipe causes a de-emphasis of about 6 dB per octave for frequencies above 1 000 Hz. The resulting frequency response has a high peak at 1000 Hz which could cause a high SINAD at the microphone output. A frequency correcting network should be placed between the microphone output and the SINAD meter input. The corrected frequency response of the acoustic coupling device shall not deviate more than 3 dB from 400 Hz to 2600 Hz.

It is very important to fix the centre of the funnel in a reproducible position relative to the receiver under test, since the position of the centre has a strong influence on the frequency response that will be measured. This can be achieved by positioning the equipment in a close-fitting fixture, supplied or specified by the manufacturer, of which the plastic funnel acoustic coupler is an integral part. Care should be taken to avoid varying the acoustic tube cross-section as the fixture is rotated.

F2.4 *Determination of the acoustic signal-to-noise ratio (manufacturer's action)*

a) Place the receiver in the acoustic coupling device and connect the equipment as illustrated in Figure F1, page 120. Make direct electrical connection to the terminals of the output transducer so that they can be connected to the SINAD meter.

b) Measure the frequency response of the combination of loudspeaker and acoustic measuring arrangement at the microphone amplifier output.

c) If the frequency response varies by more than 3 dB between 400 Hz and 2600 Hz, insert a correcting network between the microphone amplifier output and the input to the SINAD meter, that will reduce the response variation to less than 3 dB.

Note. – It may be necessary to limit the output level to a value which reduces the loudspeaker's distortion to a maximum of 5%.

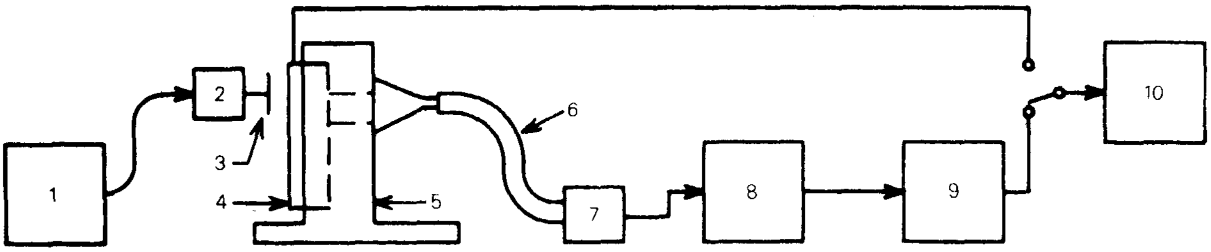
d) With the correcting network inserted, make sure that at high radio-frequency input levels there is at least a 20 dB SINAD.

e) Adjust the input radio-frequency signal level to produce a 12 dB SINAD measured by direct electrical connection to the transducer. Measure the acoustic signal-to-noise ratio on the SINAD meter connected to the output of the correcting network. Record this as the acoustic signal-to-noise ratio for this receiver and acoustic measuring arrangement.

Note. – The correcting network may nave to contain a high-input impedance and a low output impedance amplifier to ensure that the impedance of the SINAD meter does not change the frequency correcting network characteristics.

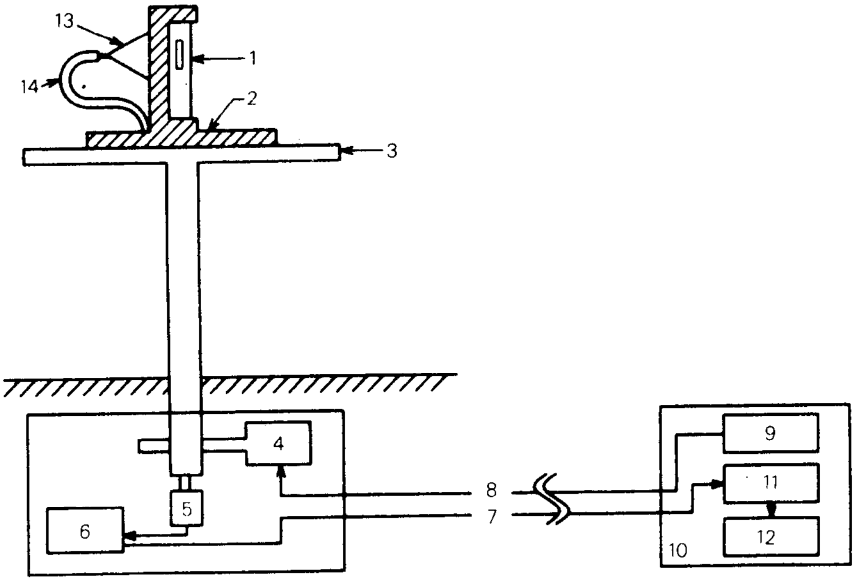
F2.5 *Using the acoustic measuring arrangement*

When the measurement of receiver output signal-to-noise ratio is required using an acoustic coupling device, connect the equipment as illustrated in Figure F1, with the receiver placed in the acoustic coupling device. Insert the correcting network supplied or specified by the manufacturer. Whenever the measurement requires that the output of the receiver be the standard signal-to-noise ratio, the output of the receiver should be set so as to obtain an acoustic signal-to-noise ratio of 12 dB.



1	Signal generator
2	Load
3	Probe
4	Equipment with integral transducers
5	Fixture for positioning the equipment under test and the plastic funnel acoustic coupler
6	Acoustic tube
7	Microphone
8	Microphone preamplifier and polarizing voltage supply (if required)
9	Correcting network with isolation amplifier
10	SINAD meter
11	Switch to select either the electrical or acoustic measurement

FIG. F1. – Test arrangement for determining the acoustic signal-to-noise ratio indication that is equivalent to the SINAD obtained by means of a direct electrical connection.



1 Equipment under test
2 Fixture for positioning the equipment under test and the plastic funnel acoustic coupler

3 Rotatable platform
4 Remotely controlled motor for rotatable platform
5 Microphone
6 Microphone amplifier and polarizing voltage supply

7 Audio-frequency cable from amplifier to off-site monitoring location
8 Remote control cable from motor to its off-site controller
9 Motor remote controller
10 Off-site signal monitor and motor controller location

11 Correcting network having an isolation amplifier (if necessary)
12 SINAD meter
13 Plastic funnel acoustic coupler

14 Acoustic tube

FIG. F2. – Rotatable platform with equipment under test for acoustic measurements to determine radio-frequency properties.

APPENDIX G

GUIDE FOR THE CONSTRUCTION OF A 30 M RADIATION TEST SITE FOR EQUIPMENT RECEIVING RADIO-FREQUENCY ELECTROMAGNETIC ENERGY

Receiver measurements can be made for all radio-frequency parameters pertaining to received radio-frequency electromagnetic energy, for example, receiver radiation sensitivity.

G1. **Test site characteristics**

	Limits
Useful frequency range:	25 MHz to 1 000 MHz
Nominal site attenuation:	20 dB to 46 dB for 25 MHz 52 dB to 78 dB for 1 000 MHz

Note. – The nominal attenuation of the test site for a half-wave dipole is 26 dB for 25 MHz and 58 dB for 1 000 MHz. The actual attenuation may vary due to ground reflections.

Equipment size limits:	6 m maximum, excluding the antenna
Radiation angle limits:	Limits only apply to the horizontal plane

See Figure G1*c* and Appendix K for tests using an alternative mounting arrangement.

See Appendix F for tests on equipment having an integral audio-frequency transducer.

G2. **Radiation test site**

The radiation test site shall be on level ground having uniform electrical characteristics and be free from reflecting objects over as wide an area as possible to ensure that extraneous electromagnetic fields do not affect the accuracy of the test results.

The minimum boundary of the test site shall be an ellipse having a 60 m major axis and a 52 m minor axis. The equipment under test and the transmitting antenna shall be located at the foci of these axes.

No extraneous conducting objects having any dimension in excess of 15 cm for measurements over the frequency range of 25 MHz to 300 MHz, or 5 cm for measurements over the frequency range of 300 MHz to 1 GHz, shall be in the immediate vicinity of the equipment under test or the transmitting antenna.

The distance between the vertical axis through the centre of the antenna of the equipment under test and the vertical axis through the centre of the transmitting antenna shall be 30 m.

All test equipment if located above ground shall preferably be powered by batteries. If the equipment is powered from the mains, each of the mains supply cables shall be provided with a suitable radio-frequency filter. The cable connecting the filter and the measuring equipment shall be screened and shall be as short as possible. The cable connecting the filter and the supply mains shall be either screened and be at ground level, or shall be buried to a depth of approximately 30 cm.

G3. **Position of the equipment under test** (see Figure G1*b*, page 128)

The equipment in its cabinet or housing in which it normally operates shall be placed on a horizontal platform, the upper side of which is 1.5 m above the ground. The platform and its support shall be made of non-conducting materials.

For equipment having an integral antenna, place the equipment on the platform in a position which is closest to its position in normal use.

For equipment having a rigid external integral antenna, mount the equipment so that the antenna is in a vertical position.

For equipment having a non-rigid external integral antenna, mount the antenna vertically with a non-conducting support.

It shall be possible to rotate the equipment about the vertical axis through the centre of the antenna of the equipment under test. It is recommended that a platform in the form of a turntable, preferably remotely controlled, should be used for this purpose.

If the equipment has a power cable, it should extend down to the turntable, and any excess cable length should be coiled on the turntable.

For information on the use of alternative mounting arrangements on this test site for equipment which is hand-carried or carried on the person while in normal operation, see Figure G1*c* and Appendix K.

G4. **Transmitting antenna**

The transmitting antenna shall be suitable for the radiation of linearly polarized waves. It may consist of a half-wave dipole, the length of which is adjusted for the frequency concerned. For practical reasons, however, a more complex antenna having high directivity and wide bandwidth is preferred.

The transmitting antenna shall be mounted at the end of a horizontal boom supported by a vertical pole, both made of non-conducting materials. The boom shall project at least 1 m from the vertical pole in the direction of the equipment under test and shall be arranged so that the centre of the antenna is 3 ± 0.2 m above the ground. The mounting shall permit the antenna to be positioned for the same polarization as that of the receiver antenna.

The cable from the antenna should be routed along the horizontal boom and the vertical pole.

At some frequencies, appreciable variations of signal level occur with small changes of antenna height due to ground reflections. The transmitting antenna, therefore, shall be moved up or down to place it in a region of low field gradient so that the test site calibration has the least possible dependence on small changes of antenna position.

G5. **Calibration antenna**

The calibration antenna replaces the equipment under test during calibration of the test site (see Figure G1*a*). The calibration antenna shall be an antenna having suitable dimensions and for which the relation between its available power output and the resultant field strength has been determined. The centre of the calibration antenna shall be located so that this point coincides approximately with the normal position of the centre of the antenna of the equipment under test. The antenna, including the cable, shall be matched to the input impedance of the selective measuring device. At frequencies below about 60 MHz, the above condition may be impossible to achieve when the antenna is arranged for vertical polarization. In this case, the lower end of the antenna should be placed 0.3 m above the ground and the equipment under test shall be positioned to satisfy the above conditions.

G6. Radio-frequency signal generator

A well-screened radio-frequency signal generator and associated output cable which connects to the transmitting antenna shall be placed in a position that will not affect the accuracy of the test results. It shall be matched to the antenna using a balun, if necessary. The connection to the generator shall be a shielded, unbalanced cable of minimum length.

G7. Selective measuring device

The selective measuring device may be a frequency selective voltmeter, a spectrum analyzer, or a calibrated field-strength meter.

The radio-frequency signal generator and the selective measuring device shall preferably be powered by batteries. If the equipment is powered from the mains, each of the mains supply cables shall be provided with a suitable radio frequency filter. The cable connecting the filter and the measuring equipment shall be screened and shall be as short as possible. The cable connecting the filter and the supply mains shall be either screened and be at ground level, or shall be buried to a depth of approximately 30 cm.

G8. Method of calibrating the test site

G8.1 Connect the equipment as illustrated in Figure G1*a* and as described in Clauses G6 and G7 with the transmitting antenna oriented to provide the polarization intended for the receiver under test.

G8.2 Adjust the frequency of the radio-frequency signal generator to the operating frequency of the receiver.

G8.3 Tune the selective measuring device to the operating frequency of the radio-frequency signal generator.

G8.4 Adjust the output level of the radio-frequency signal generator to produce a reading of 100 µV/m (40 dB (µV/m)) on the selective measuring device. Record the output of the radio-frequency signal generator in microvolts.

G8.5 The field strength for other values of the radio-frequency generator output is given by:

$$\text{field strength} = \frac{\text{new output level}}{\text{output level recorded in Sub-clause G8.4}} \times 100\,\mu\text{V/m}$$

or

$$\begin{aligned}\text{field strength} &= 40 + 20 \log (\text{new output level in } \mu\text{V}) \\ \text{in dB } (\mu\text{V/m}) &\quad - 20 \log (\text{output level in } \mu\text{V recorded in Sub-clause G8.4})\end{aligned}$$

Note. – The calibration is only valid for the frequency, antennas, polarization, and antenna position used in the calibration procedure. If any of these change, the site should be recalibrated.

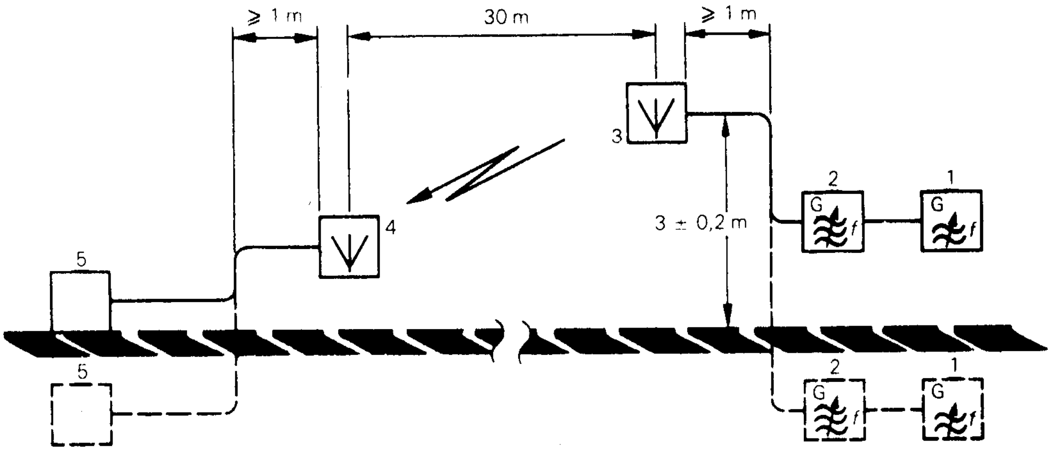


FIG. G1*a*. – Measuring arrangement for substitution measurements.

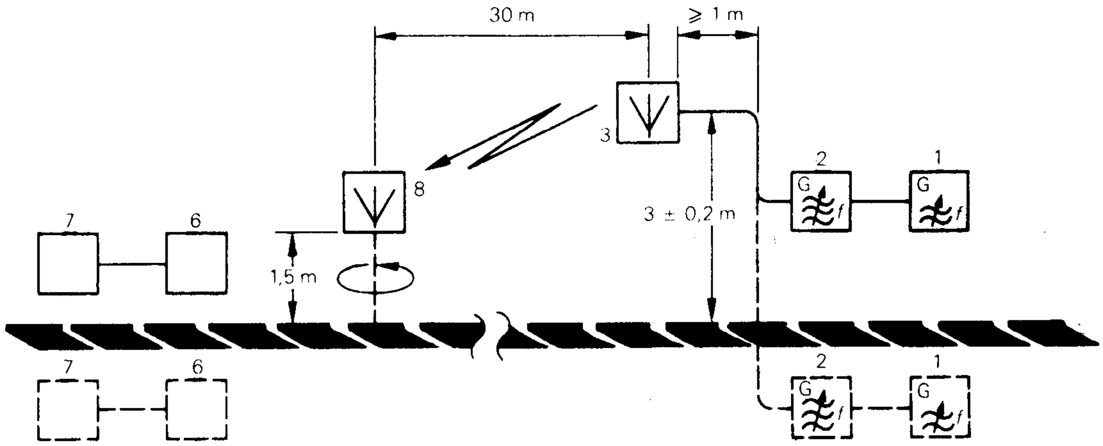


FIG. G1*b*. – Measuring arrangement for equipment under test.

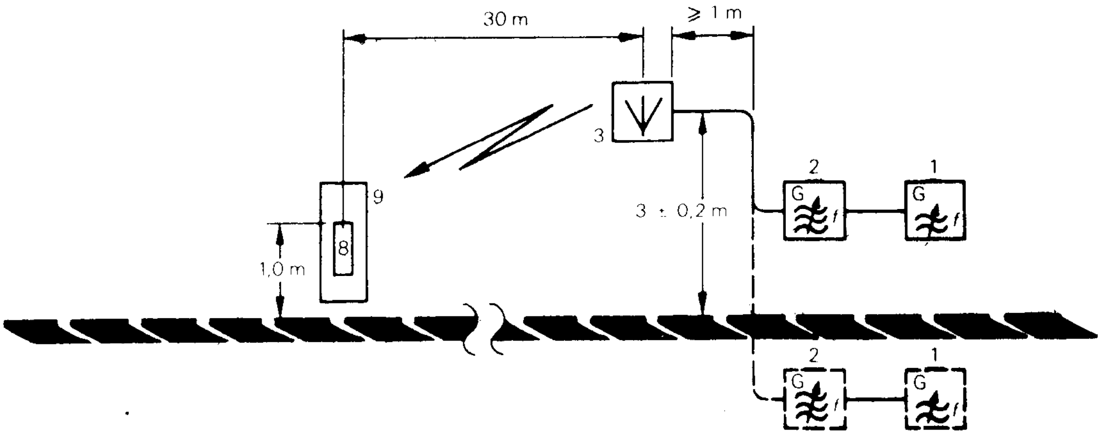


FIG. G1*c*. – Measuring arrangement for radio pagers under test.

1 audio-frequency signal generator
2 radio-frequency signal generator
3 transmitting antenna
4 calibration antenna
5 selective measuring device
6 sound level meter or sound transducer
7 distortion factor meter
8 receiver under test
9 simulated man

FIG. G1. – Measuring arrangement for receiver on a radiation test site (30 m).

APPENDIX H

GUIDE FOR THE CONSTRUCTION OF A 3 M RADIATION TEST SITE FOR MEASUREMENTS ABOVE 100 MHZ OF EQUIPMENT EMITTING RADIO-FREQUENCY ELECTROMAGNETIC ENERGY

Emission measurements can be made for all radio-frequency parameters pertaining to radiated radio-frequency electromagnetic energy, for example, transmitter radiated power, transmitter radiated spurious power, receiver radiated spurious power.

H1. **Test site characteristics**

	Limits
Useful frequency range:	100 MHz to 1 000 MHz
Nominal site attenuation:	12 dB to 38 dB for 100 MHz 32 dB to 58 dB for 1 000 MHz

Note. – The nominal attenuation of the test site for a half-wave dipole is 18 dB for 100 MHz and 38 dB for 1 000 MHz. The actual attenuation may vary due to ground reflections.

Equipment size limits:	6 m maximum, excluding the antenna
Radiation angle limits	+40° to −10°

See Appendix K for tests using an alternative mounting arrangement.

H2. **Radiation test site**

The 3 m test site described in this standard provides consistent results regardless of time or location. It permits an accuracy over the useful frequency range comparable to that achievable on larger test sites while requiring less sensitive instrumentation than on these larger sites.

The radiation test site shall be on level ground having uniform electrical characteristics and be free from reflecting objects over as wide an area as possible to ensure that extraneous electromagnetic fields do not affect the accuracy of the test results.

A continuous ground screen (either sheet metal or wire mesh having openings no greater than 1 cm in order to maintain good electrical contact between the wires) shall be used to establish a uniformly conducting ground over part of the test site. The minimum ground screen area is shown in Figure H1, page 136.

No extraneous conducting objects having any dimensions in excess of 5 cm should be present within the minimum ground screen boundary. Objects between the minimum ground screen boundary and the test site boundary shall not be such as to affect the test results.

The test site shall have a turntable and a measuring antenna mast. The distance in the horizontal plane between the vertical axis through the centre of the turntable and the vertical axis through the centre of the measuring antenna mounted on the measuring antenna mast shall be 3 m. A shelter may be provided for all or part of the test site. All such construction except for nails, hinges, etc., having no dimension greater than 5 cm should be of wood, plastic, or other non-conducting material. The wood should be impregnated to ensure minimum water absorption.

All test equipment located above ground shall preferably be powered by batteries. If the equipment is powered from the mains, each of the mains supply cables shall be provided with a suitable radio-frequency filter. The cable connecting the filter and the measuring equipment shall be screened and shall be as short as possible. The cable connecting the filter and the supply mains shall be either screened and be at ground level, or shall be buried to a depth of approximately 30 cm.

H3. **Position of the equipment under test** (see Figure H2, page 137).

The equipment in its cabinet or housing in which it normally operates shall be placed on a horizontal platform, the upper side of which is 1.5 m above the ground. The platform and its support shall be made of non-conducting materials.

For equipment having an integral antenna, place the equipment on the platform in a position which is closest to its position in normal use.

For equipment having a rigid external integral antenna, mount the equipment so that the antenna is in a vertical position.

For equipment having a non-rigid external integral antenna, mount the antenna vertically with a non-conducting support.

It shall be possible to rotate the equipment about the vertical axis through the centre of the antenna of the equipment under test. It is recommended that a platform in the form of a turntable, preferably remotely controlled, should be used for this purpose.

If the equipment has a power cable, it should extend down to the turntable, and any excess cable length should be coiled on the turntable.

For information on the use of alternative mounting arrangements on this test site for equipment which is hand-carried or carried on the person while in normal operation, see Appendix K.

H4. **Measuring antenna support**

The measuring antenna support shall consist of a horizontal boom supported by a vertical pole, both made of non-conducting materials. The boom shall project at least 1 m from the vertical pole in the direction of the equipment under test and shall be arranged so that it may be raised and lowered from 1 m to 4 m.

H5. **Measuring antenna**

The measuring antenna shall be suitable for the reception of linearly polarized waves. It may consist of a half-wave dipole, the length of which is adjusted for the frequency concerned. For practical reasons, however, or to increase the sensitivity of the measurements, it may be convenient to use a number of separate fixed broadband dipoles or more complex antennas.

The measuring antenna shall be mounted at the end of a horizontal boom. The mounting shall permit the antenna to be positioned for measuring both the horizontal and the vertical components of the electrical field. The lower end of the antenna, when oriented for vertical polarization and placed in its lowest position, shall be at least 0.3 m above the ground.

The cable from the antenna shall be routed along the horizontal boom for at least 3 m and should preferably extend, while being, at ground level, at least 3 m beyond the minimum boundary of the test site before it is connected to the selective measuring device. Alternatively, the cable may be routed underground.

H6. Auxiliary antenna

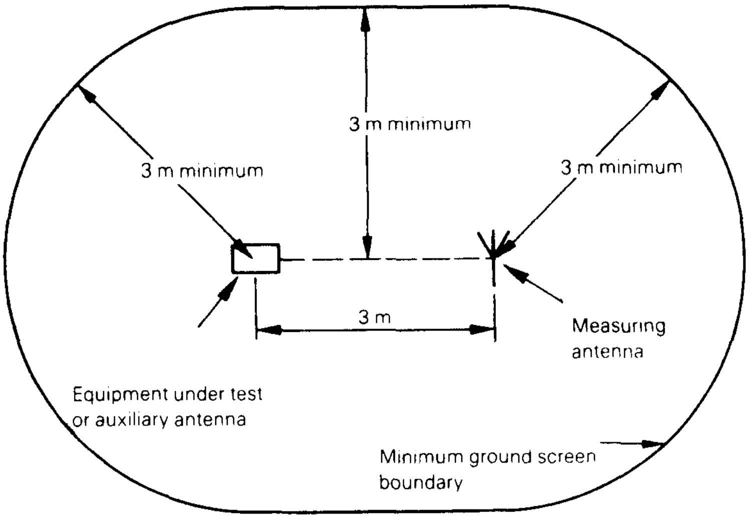
The auxiliary antenna replaces the equipment under test during part of the measurement. The auxiliary antenna shall be a half-wave dipole and shall be arranged in a manner similar to that of the measuring antenna, except that the centre of the auxiliary antenna should coincide approximately with the normal position of the centre of radiation of the equipment under test.

H7. Radio-frequency signal generator

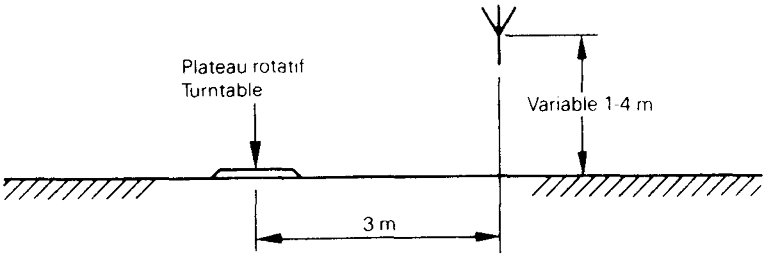
A well-shielded radio-frequency signal generator, with a matching or combining network (if required) and its associated output cable, shall be placed in a position such that it will not affect the accuracy of the test results, and shall be connected to and matched to the auxiliary antenna.

H8. Selective measuring device

The selective measuring device may be a frequency selective voltmeter, a spectrum analyzer, or a calibrated field-strength meter, and shall be placed, together with its associated input cable, in a position such that it shall not affect the accuracy of the test results.


3 m minimum
3 m minimum
3 m minimum
3 m
Measuring antenna
Equipment under test or auxiliary antenna
Minimum ground screen boundary

Vue de dessus
Top view



Side view

FIG. H1. – 3 m site dimensions inside the ground screen boundary.

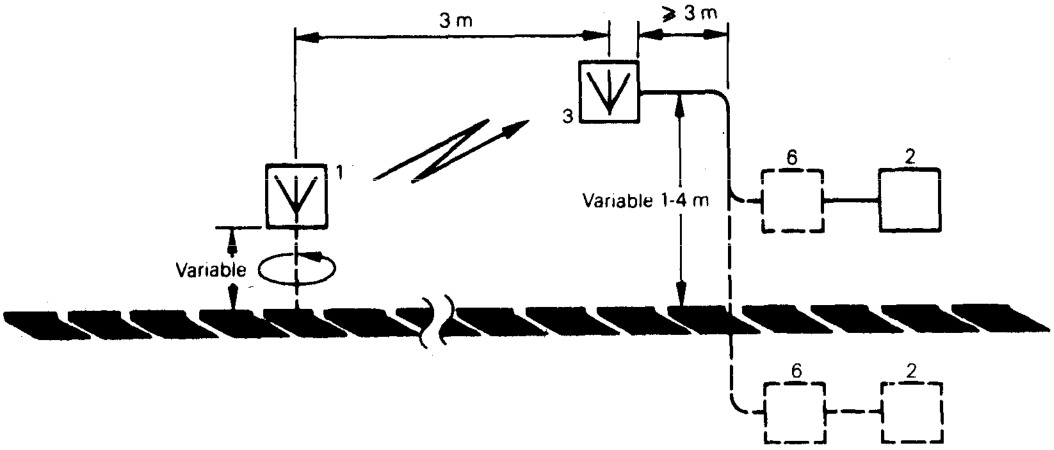


FIG. H2*a*. – Measuring arrangement for the equipment under test.

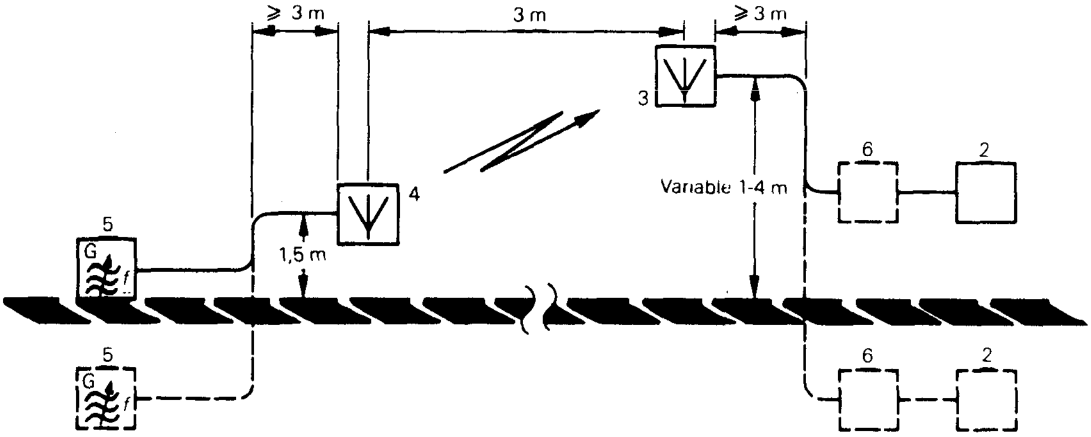


FIG. H2*b*. – Measuring arrangement for substitution measurement.

1 = equipment under test
2 = selective measuring device
3 = measuring antenna
4 = auxiliary antenna
5 = radio-frequency signal generator
6 = optional calibrated attenuator for measuring the effective radiated power, or fundamental oscillation rejection filter for measuring non-essential emissions

FIG. H2. – Measuring arrangement for radio-frequency emission (3 m).

APPENDIX J

GUIDE FOR THE CONSTRUCTION AND MEASUREMENT OF A RADIO-FREQUENCY COUPLING DEVICE (RFCD)

The equipment parameter measurements applicable to this radio-frequency coupling device (RFCD) are all ratio measurements pertaining to receiver radio-frequency energy, for example, receiver selectivity, spurious-response immunity, intermodulation immunity.

RFCDs for higher frequency ranges are under consideration.

J1. **RFCD characteristics**

	Limits	
Useful frequency range	1 to 200 MHz for Size I 1 to 100 MHz for Size II	
Available field strength in RFCD	See Clause J5	
	Size I	*Size II*
Equipment size limits (antenna included)	Length = 200 mm	400 mm
	Width = 200 mm	400 mm
	Height = 250 mm	500 mm

J2. **RFCD construction**

The RFCD is a transmission line of the stripline class.

The RFCD is made of three pieces of highly conductive metal (for example, copper sheet) that are sufficiently rigid (for example, strengthened by wood) to support the equipment under test mounted in the stripline.

The shape and size of the RFCD is shown in Figure J1, page 144. It is open on both sides. The RFCD has an impedance of 100 Ω and shall be terminated with this impedance by resistance having less than 5 Ω of reactance at any frequency from 1 MHz to 200 MHz. Both outer conductors are connected by the shielding of the transmission line.

The RFCD shall be matched to the transmission line impedance with matching networks (see Figures J2 and J3, page 145) with resistors that have less than 5% reactance at any frequency from 1 MHz to 200 MHz (for example, for a 50 Ω transmission line, a shunt and series resistance of 70.7 Ω should be used).

Care should be taken to choose resistors with very low inductance and capacitance (for example, surface mounted resistors) because the size and the material of the resistors have a great influence on the reactance at frequencies especially above 100 MHz.

J3. **Measurement of the RFCD**

After constructing the RFCD, it is necessary to measure the r. f. behaviour of the RFCD in the frequency range from 1 MHz to 200 MHz to determine at what frequency and by how much the field strength deviates from a constant value.

J3.1 *Method of measurement*

A 40 mm monopole antenna, which is short in comparison to ¼ wavelength for the highest measuring frequency, is mounted on the lower outer conductor, pointing to the inside of the stripline. The antenna base shall be located in the centre of the area designated to locate the receiver under test. This monopole is connected at the antenna base to a 50 Ω, 20 dB pad, and from there with a low-loss cable to the selective measuring device.

Connect a radio-frequency signal generator followed by an amplifier if necessary and apply 1 V to the input of the RFCD.

The 40 mm monopole antenna has an impedance which is, for practical purposes, capacitive and which gives a voltage, in a constant field strength, that will increase by 6 dB for each time the frequency is increased by a factor of 2.

Vary the frequency from 1 MHz to 200 MHz in steps not greater than 3% and record the frequency and the reading of the selective measuring device.

J3.2 *Presentation of results*

Note. – See Figure J4, page 146, for an example graph.

a) Convert the selective measuring device readings recorded in Clause J3.1 to dB (μV).

b) Plot on a graph the frequency values recorded in Sub-clause J3.1 on a log scale and the dB (μV) values converted in Step *a)* on a linear scale.

c) Fit a straight line, with increases of 6 dB for each time the frequency is increased by a factor of 2, to the points plotted on the graph.

d) At any frequency the difference between the straight line and the plotted value is the deviation. This is used to correct the spurious-response measurement. The deviation is subtracted from the measurement (see Sub-clause 29.5.3, Step *a)*).

J4. Position of the equipment under test

The equipment under test shall be mounted on a pedestal made of a low dielectric material (dielectric constant of less than 2) which places it at least 10 mm above the lower conductor. The equipment shall be centered in the horizontal plane of the RFCD in the following position:

a) For equipment having an integral antenna, mount the equipment so that the antenna is in a vertical position, with that axis vertical which is closest to vertical in normal use.

b) For equipment having a rigid external integral antenna, mount the equipment so that the antenna is in a vertical position.

c) For equipment with a non-rigid external integral antenna, mount the antenna vertically with a non-conducting support.

d) Or as agreed with the manufacturer.

J5. Explication of the term "available field strength in a radiation stripline"

Note. – The measurements in this standard that use the RFCD are of the ratio type and are made in terms of the ratio of the voltages applied to the input of the RFCD. Therefore, knowledge of the absolute value of the field strength in the RFCD is not required.

The following information is provided for those who wish to know the values of the field strengths involved in the measurements:

The available field strength is equal to the voltage on the centre conductor divided by the distance from the centre conductor to the outer conductor in meters. The relationship of the field strength in the RFCD to the input voltage is given by the following formula:

$$\text{field strength} = V_i \times C \times A \times \frac{1}{H} \quad \frac{\mu V}{m}$$

where:

V_i is the voltage in µV at the input to the RFCD

A is the voltage ratio of the voltage on the centre conductor to V_i ana in this RFCD is equal to 100/170.7 or 0.5858

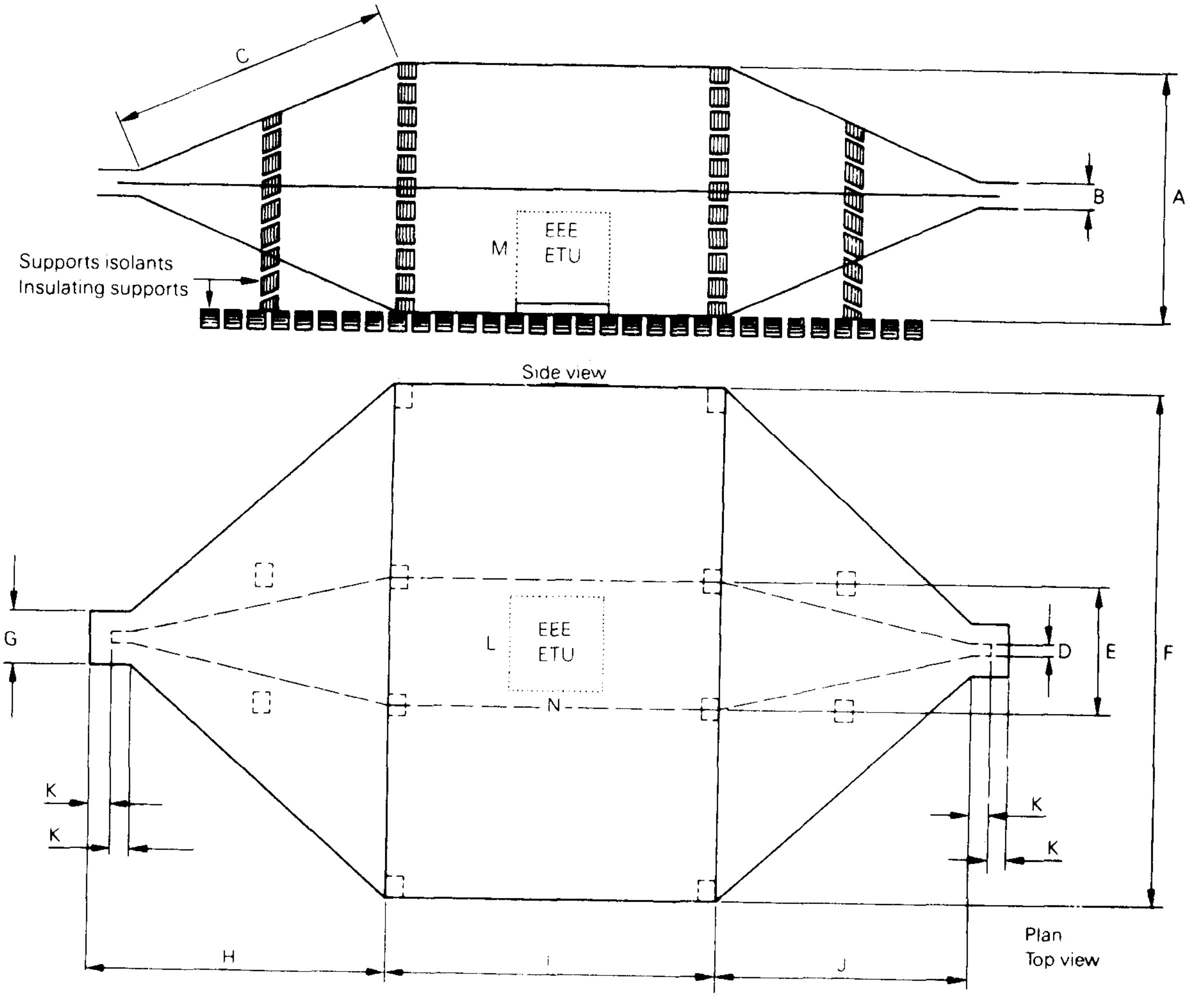
H is the distance, in meters, between the outer conductor and the centre conductor, and is equal to 0.3 m for Size I and 0.6 m for Size II

C is a constant

V_i is determined in the same way that the input voltage to a receiver is determined (for example, the radio-frequency signal generator output reduced by any losses due to attenuators. cables, combining or matching networks). V_i should be determined for each measuring device and each frequency used in the measurement.

If the radio-frequency signal generator output is calibrated in µV (e. m. f.), then C is 0.5.

If the radio-frequency signal generator output is calibrated in µV (matched-load [ml]), then C is 1.



Dimensions in millimetres

	Dimensions Size I	Dimensions Size II
A	600	1200
B	60	120
C	658	1316
D	31	62
E	312	624
F	1250	2500
G	125	250
H	700	1350
I	800	1500
J	600	1200
K	50	75
L	200	400
M	250	500
N	200	400

FIG. J1. – RFCD (stripline).

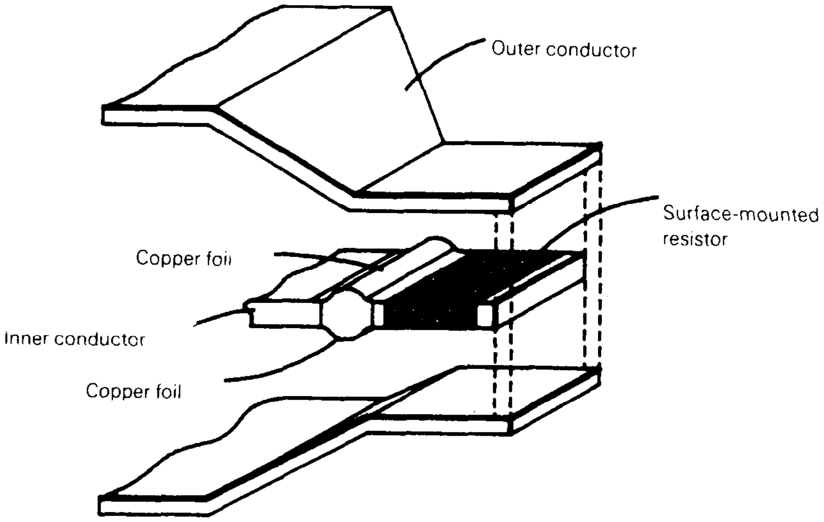


FIG. J2. – Detail of stripline load.

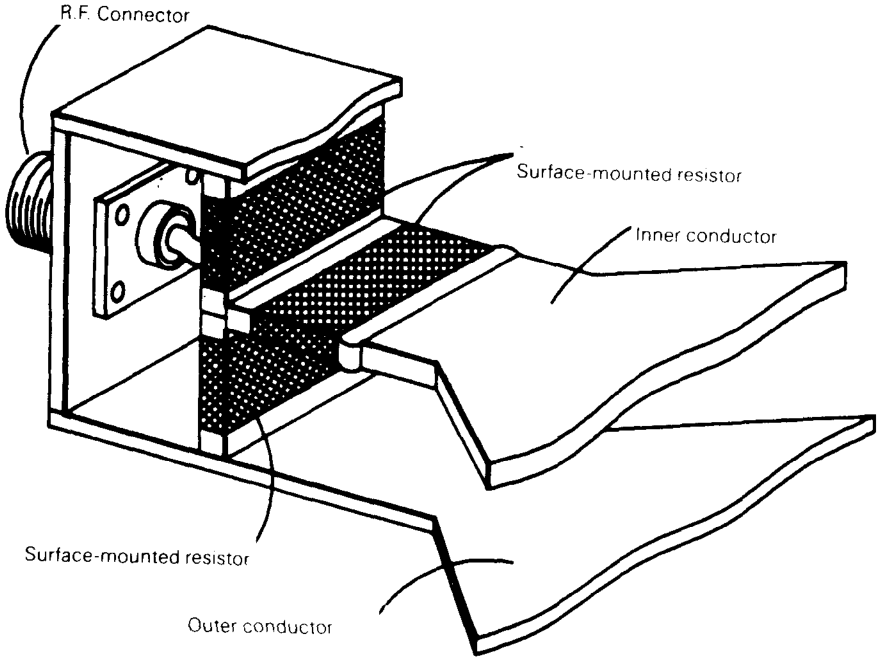


FIG. J3. – Detail of stripline input matching resistor.

Antenna voltage versus frequency (example)

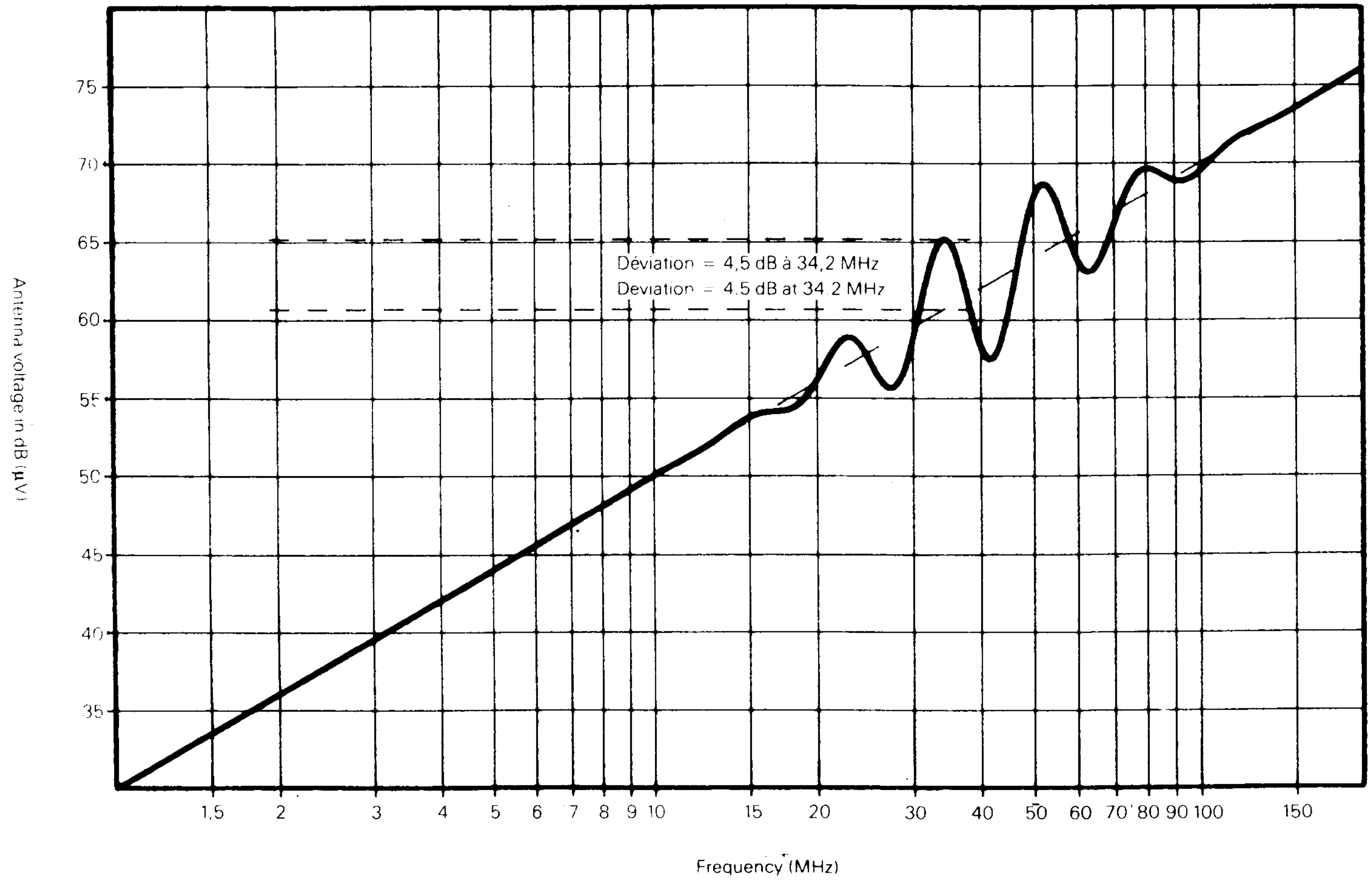


FIG. J4. – Antenna voltage versus frequency.

APPENDIX K

ALTERNATIVE TEST MOUNTING ARRANGEMENTS FOR EQUIPMENT WHICH IS HAND-CARRIED OR CARRIED ON THE PERSON WHILE IN NORMAL OPERATION

K1. **Simulated-man test device**

Most radio paging receivers have an integral antenna. In normal operation, the radio pager is worn on the person and most often is clipped to the clothing at the person's waist. Radio paging antennas are designed for optimum performance when worn on the person. Therefore, to standardize the radio paging radiation sensitivity measurements, a test device is used to simulate the human body. This test device consists of a standard container filled with salt water, and is referred to in this appendix as the "simulated man".

The simulated man is used to measure the reference radiation sensitivity (selective calling) and/or average radiation sensitivity (selective calling) of radio pagers.

K1.1 *Description*

Material	Cast acrylic tube closed at both ends
Height	1.7 ± 0.1 m
Outside diameter	305 ± 2 mm
Sidewall thickness	4.8 ± 0.2 mm
Top and bottom thickness	30 ± 2 mm

Filled with salt (NaCl) solution of 1.49 g per litre of distilled water (H_2O).

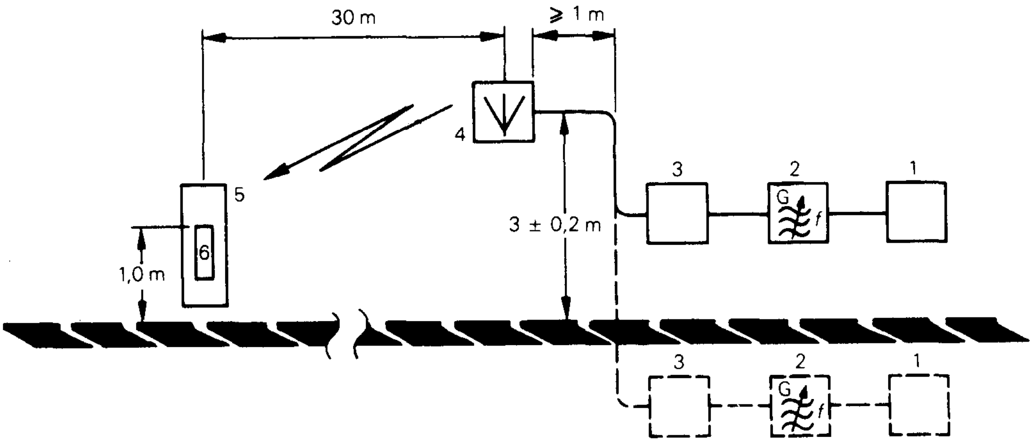
The simulated man shall rest on the surface of the radiation site.

K1.2 *Location of radio pager for measurement*

The top of the radio pager should be 1.0 ± 0.1 m from the ground. The radio pager should be fixed on the surface of the simulated man without a gap between them.

K2. **Simulated hand**

Under consideration.



1 = encoder
2 = radio-frequency generator
3 = 80 dB step attenuator, steps of 1 dB
4 = transmitting antenna
5 = simulated man
6 = receiver under test

Note. – Care should be taken to ensure that the field in the vicinity of the receiver under test is not disturbed by the test equipment.

FIG. K1. – Measuring arrangement for radio pagers on a radiation test site (30 m).

APPENDIX L

GUIDE FOR THE CONSTRUCTION OF A 30 M RADIATION TEST SITE FOR EQUIPMENT EMITTING RADIO-FREQUENCY ELECTROMAGNETIC ENERGY

Emission measurements can be made for all radio-frequency parameters pertaining to radiated radio-frequency electromagnetic energy, for example, transmitter radiated power, transmitter radiated spurious power, receiver radiated spurious power.

L1. **Test site characteristics**

	Limits
Useful frequency range	25 MHz to 1 000 MHz
Nominal site attenuation	20 dB to 46 dB for 25 MHz 52 dB to 78 dB for 1 000 MHz

Note. – The nominal attenuation of the test site for a half-wave dipole is 26 dB for 25 MHz and 58 dB for 1 000 MHz. The actual attenuation may vary due to ground reflections.

Equipment size limits	6 m maximum, excluding the antenna
Radiation angle limits	Limits only apply to the horizontal plane

See Appendix K for tests using an alternative mounting arrangement.

L2. **Radiation test site**

The radiation test site shall be on level ground having uniform electrical characteristics and be free from reflecting objects over as wide an area as possible to ensure that extraneous electromagnetic fields do not affect the accuracy of the test results.

The minimum boundary of the test site shall be an ellipse having a 60 m major axis and a 52 m minor axis. The equipment under test and the transmitting antenna shall be located at the foci of the axes.

No extraneous conducting objects having any dimension in excess of 15 cm for measurements over the frequency range of 25 MHz to 300 MHz, or 5 cm for measurements over the frequency range of 300 MHz to 1 GHz, shall be in the immediate vicinity of the equipment under test or the transmitting antenna.

The distance between the vertical axis through the centre of the antenna of the equipment under test and the vertical axis through the centre of the transmitting antenna shall be 30 m.

All test equipment if located above ground shall preferably be powered by batteries. If the equipment is powered from the mains, each of the mains supply cables shall be provided with a suitable radio frequency filter. The cable connecting the filter and the measuring equipment shall be screened and shall be as short as possible. The cable connecting the filter and the supply mains shall be either screened and be at ground level, or shall be buried to a depth of approximately 30 cm.

L3. Position of the equipment under test (see Figure L1)

A pedestal shall be placed on a turntable so that the pedestal's upper horizontal surface will be 1.5 m above ground. The equipment under test in the cabinet or housing in which it normally operates shall be placed on the upper horizontal surface of the pedestal. Both the turntable and the pedestal shall be made of non-conducting materials.

For equipment having an integral antenna, place the equipment on the platform in a position which is closest to its position in normal use.

For equipment having a rigid external integral antenna, mount the equipment so that the antenna is in a vertical position.

For equipment having a non-rigid external antenna, mount the antenna vertically with a non-conducting support.

It shall be possible to rotate the equipment about the vertical axis through the centre of the antenna of the equipment under test. It is recommended that a platform in the form of a turntable, preferably remotely controlled, should be used for this purpose.

If the equipment has a power cable, it should extend down to the turntable, and any excess cable length should be coiled on the turntable.

For information on the use of alternative mounting arrangements on this test site for equipment which is hand-carried or carried on the person while in normal operation, see Appendix K.

L4. Measuring antenna support

The measuring antenna support shall consist of a horizontal boom supported by a vertical pole, both made of non-conducting materials. The boom shall project at least 1 m from the vertical pole in the direction of the equipment under test and shall be arranged so that it may be raised and lowered from 1 m to 4 m.

L5. Measuring antenna

The measuring antenna shall be suitable for the reception of linearly polarized waves. It may consist of a half-wave dipole, the length of which is adjusted for the frequency concerned. For practical reasons, however, or to increase the sensitivity of the measurements, it may be convenient to use a number of separate fixed broadband dipoles or more complex antennas.

The measuring antenna shall be mounted at the end of a horizontal boom. The mounting shall permit the antenna to be positioned for measuring both the horizontal and the vertical components of the electrical field. The lower end of the antenna when oriented for vertical polarization and placed in its lowest position, shall be at least 0.3 m above the ground.

The cable from the antenna shall be routed along the horizontal boom for at least 3 m, and should preferably extend, while being at ground level, at least 3 m beyond the minimum boundary of the test site before it is connected to the selective measuring device. Alternatively, the cable may be routed underground.

L6. Auxiliary antenna

The auxiliary antenna replaces the equipment under test during part of the measurement. The auxiliary antenna shall be a half-wave dipole and shall be arranged in a manner similar to that of the measuring antenna, except that the centre of the auxiliary antenna should coincide approximately with the normal position of the centre of radiation of the equipment under test.

L7. Radio frequency signal generator

A well-shielded radio-frequency signal generator with a matching or combining network (if required) and its associated output cable, shall be placed in a position such that it will not affect the accuracy of the test results, and shall be connected to and matched to the auxiliary antenna.

At frequencies below about 60 MHz, the above condition is impossible to achieve when the antenna is arranged for vertical polarization. In this case, the lower end of the dipole shall be placed 0.3 m above ground.

L8. Selective measuring device

The selective measuring device may be a frequency selective voltmeter, a spectrum analyzer, or a calibrated field-strength meter, and shall be placed, together with its associated input cable, in a position such that it shall not affect the accuracy of the test results.

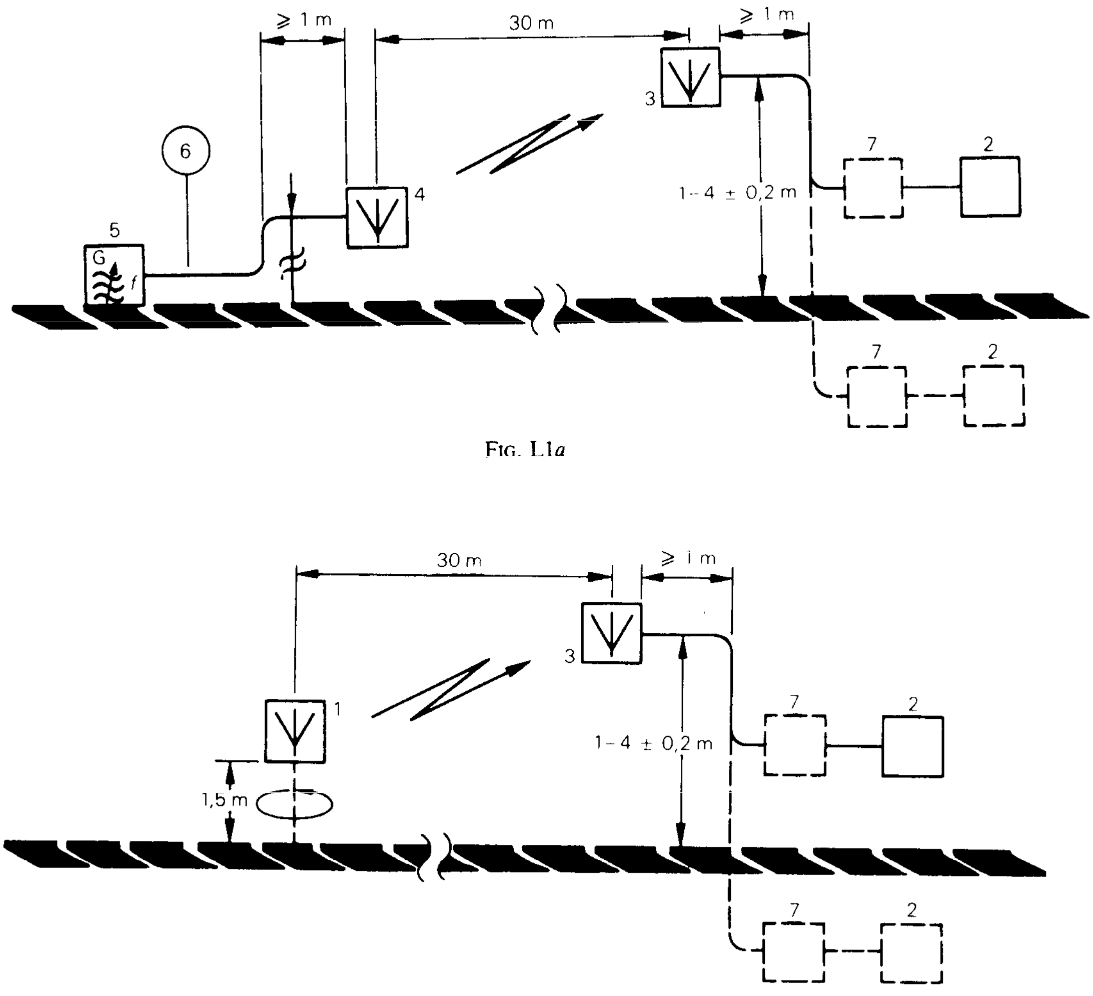


Fig. L1*a*

Fig. L1*b*

1 = transmitter under test
2 = selective measuring device
3 = measuring antenna
4 = auxiliary antenna
5 = radio-frequency signal generator
6 = selective measuring device
7 = optional calibrated attenuator for measuring the effective radiated power, or fundamental oscillation rejection filter for measuring non-essential emissions

Fig. L1. – Measuring arrangement for transmitter at 30 m.